RUM JUNGLE REHABILITATION PROJECT

ENGINEERING REPORT
MAY 1982

FOR

THE NORTHERN TERRITORY OF AUSTRALIA

DEPARTMENT OF TRANSPORT AND WORKS

BY

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Volumes 1, 2 & 3

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EXECUTIVE SUMMARY

The contents of this Engineering Report - May 1982 has covered all aspects of the proposed rehabilitation works to be carried out at Rum Jungle.

Previous recommendations of measures to be adopted have been studied in more detail with the object of proposing activities that should achieve the standard of rehabilitation considered appropriate by the Commonwealth Government.

The report confined its studies and investigations to the Strategy D measures put forward in 'The Summary' - April 1978 from which certain metal pollution reductions would result from the implementation of various activities.

The investigations carried out during March to May 1982 have provided further information on the proposed measures to be adopted and this report has recommended some of Strategy D measures be changed for a more cost effective solution and to achieve a higher probability of long term success.

The rehabilitation standards have remained the prime objective when considering the total project works.

This report recommends the expenditure of $17.3 M dollars (July 1982 dollars) to achieve the standards of rehabilitation considered appropriate by both Commonwealth and N.T. Governments.

All project activities can be achieved in a three year time frame, provided the project commencement date is no later than the 1st October, 1982.

The water treatment plant study has provided details of a suitable plant and its associated costs to properly treat and discharge all contaminated water. Previous reports had no detailed information available on a method of water treatment hence the estimates for the plant were not representative.

As a result of the study the cost of the water treatment is significant and it is recommended that the Commonwealth Government reconsider the funds considered appropriate for the works and approve an additional amount for the water treatment plant.

The only other alternative is a reduction in other measures to accommodate the additional water treatment costs. It is not recommended to delete treatment of the open cut pit water.

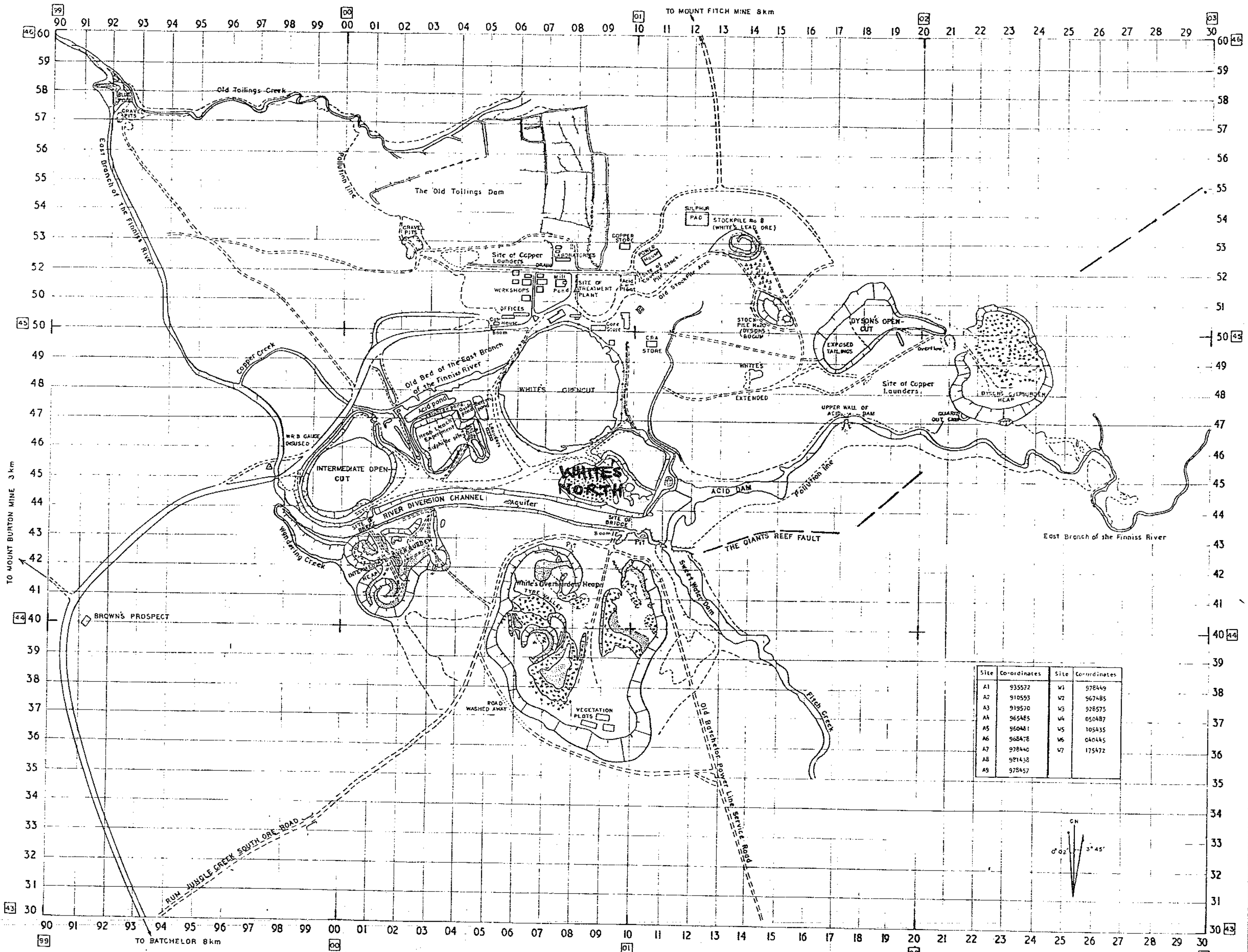
It is expected to achieve the standards of rehabilitation once all measures recommended in this report have been implemented.

All measures have been selected using current technology with a low probability of failure or technical complications.

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	910593	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		

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

Demarcation line — pollution 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 A TREATMENT PLANT
EAST: 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 — 06 0 060
NORTH: 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 — 51 4 514
REFERENCE 060514

SECTION 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Purpose of the Report

The Engineering Report has been prepared to present a plan of execution for rehabilitation of the Rum Jungle mine site.

It has included all aspects of

- the anticipated standard of rehabilitation
- the measures to be adopted
- the costs to implement such measures
- the time frame for undertaking the work

A report prepared by the Working Group in 1978 - hereafter referred to as 'The Summary' provided a number of alternative strategies and the expected levels of rehabilitation for each alternative. It also recommended further investigations to solve some of the more complex problems and to provide more information needed to achieve a more accurate estimate of cost for the proposed measures to be adopted.

The Commonwealth Government endorsed Strategy D from 'The Summary' and "noted that the program was estimated to cost a total of $12.14 M (February 1980 prices) over four years."

The Northern Territory Government presented an Implementation Report in October 1981 which recommended further investigations be carried out prior to a final 'Engineering Report' being prepared.

The scope of the investigation program was agreed between the Commonwealth and N.T. Governments in March, 1982.

This Engineering Report contains the results of the investigations and makes recommendations for the measures to be adopted. In some cases the measures recommended in this report vary from the proposed strategy D proposals. Reasons for the departures have been given.

The measures recommended should provide a more effective solution to the problems involved and achieve the desired rehabilitation objective.

1.2 The Problem

The Rum Jungle Mine is situated 64 kilometres south of Darwin on the East Finniss River.

Mining activities ceased in 1971 after some 13 years of operations during which time uranium, copper, manganese and zinc were recovered from open cut and underground workings.

The methods of waste disposal used at the time were within the allowable regulations that existed, however in August 1977 the Deputy Prime Minister, Mr. Anthony announced Government decisions in respect to the development of Australia's uranium resources which included a statement asserting that the Rum Jungle project was carried out with inadequate concern for the environment and would not be permitted by today's (1977) standards.

The Rum Jungle area has three major categories of problems which can be summarised as:

1.2.1 Finniss River Pollution

Each year during the wet season, the East Branch of the Finniss River carries a substantial amount of copper, manganese and zinc, from the Rum Jungle area, as a result of oxidation, of overburden heaps and the presence of acid caused by bacteriological action within the same overburden heaps.

The combined effect causes the release of acidified water and metal ions into the river each wet season, which is discharged into the Finniss River system.

1.2.2 Public Health and Safety Risks

Within the area of the mine there exists some potential hazards to public health and safety.

The White's, Intermediate and Dysons open cut contain large volumes of contaminated water which is not fit for human consumption. In particular the White's Open Cut pit contains low p.H. water which if used as a recreation area would have adverse effects on the public at large.

The treatment plant tailings were discharged over 34 hectares of the mine site and contain acidic and radioactive waste products.

Its' location permits migration of tailings, during the wet season, into the local creeks.

The same area during the dry season is subject to wind erosion and poses a potential radiological health hazard if permanent habitation was permitted.

Some creeks have dangerous quicksand deposits along the banks and there are a number of old evaporation ponds and tributary creeks holding acidic water and heavy metal sludges.

1.2.3 Despoliation of the Natural Landscape

There is approximately 200 hectares of land in the immediate Rum Jungle area which has been significantly affected by the mining operations and the waste disposal systems adopted.

The overburden heaps and lack of vegetation and areas affected by acidic wastes are the main influences on the landscape.

Some of the creeks, both upstream and downstream have been affected by acidic wastes and migration of mine waste products.

SECTION 2

STANDARD OF REHABILITATION

2.0 STANDARDS OF REHABILITATION

2.1 Expected Standard of Rehabilitation

'The Summary' recommended measures that could be adopted and the expected level of pollution reduction.

The Commonwealth Government approved in principle 'strategy D' measures which had the following expected levels of pollution reduction:

70% reduction in copper pollution occuring in water courses.
70% reduction in zinc pollution occuring in water courses.
56% reduction in manganese pollution occuring in water courses.
78% notional benefits which included pollution reduction, improvement to public health hazards and aesthetic improvement to the mine site landscape.

The Implementation Report put forward design targets, that were designed to achieve the expected reduction in pollution sources stated above, in order to provide a means to practically measure the pollution, so engineering works could be controlled and the success of the rehabilitation works demonstrated from water samples, photography and other control tests.

The design targets were formulated using current standards, best practical technology and a proposed discharge from the site that could meet the standard of rehabilitation expected, after adoption of strategy D measures.

It must be stressed that the design targets put forward in this report are for engineering guidence and development of design criteria.

They do not relate to any Government standard and may, during the course of the rehabilitation works, require review and possible change.

The objective will be to achieve the metal pollution reductions stated and make substantial improvements to the health hazards and landscape aesthetics.

One other important aspect in the overall concept adopted in this report, is the cost of the works.

The $12.14 M (1980 dollars) has been considered in the overall assessment of the measures to be adopted and an appropriate scope of work has been incorporated in the project to achieve all objectives.

2.2 Project Design Targets

The following design targets shall be considered appropriate for the development of engineering criteria for the rehabilitation works.

They were previously put forward in the Implementation Report in October 1981 and generally discussed at subsequent meetings, with Commonwealth Government officers. Some changes have been made to take into account comments expressed at those meetings.

2.2.1 Expected Life of the Rehabilitation Works

To permit selection of practical engineering solutions to the problems at Rum Jungle it was necessary to establish the estimated life that the selected measure must endure in order to achieve the expected rehabilitation standards.

'Strategy D' proposes the use of impervious clay and soil caps to prevent water ingress into reshaped overburden heaps and the 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 economics of the rehabilitation works and the period in which the mining operations took place, this report recommends a 100 year life be adopted for all protection works undertaken.

The vegetation works proposed would provide early soil stabilisation to prevent erosion of impervious soil covers during each wet season. The vegetation programme is expected to improve each year and provide soil stability for longer than 100 years.

2.2.2 Water Quality Targets

This report has considered the reduction of heavy metals expected from 'Strategy D' proposals and it is the recommendation of the N.T. Water Division and Department of Health to use as a guide, the criteria set out in p.2. of the 1980 publication prepared by the - National Health and Medical Research Council/Australia Water Resources Council for the "Desirable Quality for Drinking Water in Australia".

Calcium, sulphates and radionuclide concentrations are exceptions from the table. They are 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 Water Quality Design Targets

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

- the anticipated release using 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 'Strategy 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 targets 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 to be released using one possible method of open cut water treatment.

By using the recommended targets in this report, a higher level of copper release is permissible than 'Strategy D' 70% reduction criteria. The level of manganese must be lower than the 56% reduction criteria.

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

Column 3: The Canadian Standard for Metal Mining Liquid Effluent Regulations - taken from the Canadian Gazette Part 11, Vol. 111, 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 design targets 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.

TABLE 1

	COLUMN 1	COLUMN 2	COLUMN 3
	THEORETICAL RELEASE FROM RUM JUNGLE AFTER REHABILITATION BASED ON 'OPTION D' PERCENTAGES	RUM JUNGLE WATER QUALITY DESIGN TARGETS	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	Not Known	200	
Chloride		600	
Copper	0.53	1.5	0.6
Total Iron		1.0	
Magnesium		150	
Manganese	0.83	0.5	
** Sulphate	Not Known	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	
Cadmium		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

** Targets 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 edition p.36 Table 2)

(c) Methylene Blue Active Substances

Water Quality Measurement -

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 of the rehabilitation measures.

The design targets set out in table 1 will be considered as receiving water targets at the Finniss River sampling station.

General Water Quality Targets -

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 target. The margin between the expected release from Rum Jungle and the recommended targets is sufficient to account for the existing background levels in the water reaching the site.

Interim Water Quality Targets -

Two design targets are expected to be exceeded during the rehabilitation programme which may affect the Finniss River to a greater extent than is presently experienced, if underground injection of treated water cannot be achieved.

It is expected to have an excess of dissolved calcium 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 'Strategy D' alternatives which proposes to remove water from Whites 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 of 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 of the Finniss River during the wet season (see Table 1 p.7 of 'The Summary') would indicate sufficient volume to achieve the desired 10:1 dilution that appears necessary to satisfactorily reduce calcium and sulphate levels during release of treated open cut water. The added effect of the Finniss River dilution should ensure a high factor of safety in achieving the required targets 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. A publication 'Compilation of Aust. Water Quality' by B.T. Hart - technical paper No. 7 of 1974 noted that certain brown trout have survived in water of 1800 mg/l concentrations.
3. Vegetation & Aesthetic Effects	If underground injection of treated water during the dry season cannot be achieved it may be necessary to dilute treated water with supplemented ground water. It is expected that surface encrustations may 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 release programme until the peak of the wet season thus allowing early flow in both river arms to remove the previous year's 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 may be expected for possibly 3 years after the completion of the water treatment programme, if the underground injection method cannot be implemented.

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.

   There is a standard LC_{50}^{96} test described in a paper by B. Hart which could determine the acceptable levels to be used, however the tests taken 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 previous reports should provide sufficient data.

3. Vegetation & Aesthetic Effects — There should be no harmful effects to vegetation in the Finniss River. Some calcium sulphate may precipitate during the dry season.

It should be noted that the East Branch of the Finniss River will carry the higher levels of calcium, sulphate and heavy metals during the rehabilitation period, but it is of no consequence until the acidic soil surrounding the river course has been treated and new vegetation 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.

2.2.3 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 N.T. Dept. of Health will 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 'Strategy D' design parameters. The criteria for a 100 year life of the cover is expected to exceed any radiation requirements, so use of these radiation design targets 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 following should be considered arbitrary rehabilitation targets for the relevant radiological parameters.

External Radiation

Suggested Limit	. 80μRem.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 ≅ 1000μRem.h^{-1} (10μSv.h^{-1}) . reduction factor required ≅ 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&MRS limit for general public 500 mRem.y^{-1} (5 mSv.y^{-1})

Radon/Radon Daughter Concentration

Suggested Limit	. 1 pCi.1^{-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 ≅ 120 cm compact soil OR ≅ 200 cm soil . required thicknesses (2 layers) (30 cm clay OR ((30 cm compact soil (30 cm clay OR ((50 cm soil (60 cm compact soil OR ((100 cm soil
Impact on Public	. for full time exposure 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 . surface and groundwater
. yearly average

This section on radionuclide contamination does not apply to the remanent water in the open cuts after the rehabilitation programme has been completed.

Location . applicable at monitoring site 0.1 km downstream of East Finniss/Finniss River confluence

Impact on Project . little impact on project maximum concentration in Tailings Creek

Impact on Public . standards equivalent to NHMRC and 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 . 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 on 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 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.

2.2.4 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 rehabilitation 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 design phase of the project.

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 once seeding has been completed in each area. Some contingency for replanting will be necessary and can only be assessed on as 'as required' basis.

Plant Population - to achieve an aesthetically satisfactory revegetation programme it is desirable to have 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 heaps and tailings cover. Aesthetics will again become of secondary consideration when considered against the reduction of metal pollution in 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 will 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 heaps in the Rum Jungle area.

2.2.5 Fauna/Fisheries Rehabilitation -

It is recommended that the current fauna population in the surrounding areas outside the Rum Jungle affected area, be the required target, once all works have been 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 have been removed a rapid migration of local fauna is considered likely due to superior grazing conditions expected in the rehabilitation 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 quantitive measures of the overall success of the project.

A lack of substantial aquatic population data at the time of this report prevents an aquatic target being set. The measures to be adopted should not create any reduction in the aquatic life in the Finniss River system and allow regeneration in the East branch after some years.

2.2.6 Land Use -

The future use of the Rum Jungle land area has been considered and it is important in its relation to other targets 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 Implementation Report. (October 1981).

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.

It is recommended that no permanent inhabitants be permitted within the 200 hectare site and 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 Government.

It is intended that the water in Intermediate and Whites Open Cut pits be returned to a safe recreational standard, however it may require some monitoring and adjustment after completion of the initial treatment before unrestricted public access is permitted.

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.

The alternative use of the area for future mining and exploration, restrictions on inhabitatnts and fauna management should not be viewed as a change to these recommended standards.

SECTION 3

MEASURES TO BE ADOPTED

3.0 MEASURES TO BE ADOPTED

'The Summary' presented a number of alternatives, and the expected levels of pollution reduction for each case from which the Commonwealth Government endorsed 'strategy D' measures.

The Department of Housing and Construction - Canberra Region, (hereafter referred to as the D.H.C.) provided a check estimate for 'strategy D' proposals. Their estimate formed the basis of the $12.14 M (1980 dollars) funds considered to be appropriate by the Commonwealth Government for the works.

The scope of work included in the estimate varied in some cases from the original 'strategy D' methods. The D.H.C. revised scope of work has been included in the 'strategy D' summary below for comparison with the recommendations made in this report.

3.1 Strategy D Recommendations

3.1.1 Copper Heap Leach Pile -

Remove the copper heap leach pile and dump into the adjacent Whites Open Cut.

Remove the existing evaporation ponds launders and structures, re contour the surrounding area and revegetate.

3.1.2 Tailings Dam -

Treat acidic soil and tailings with lime to raise the p.H.

Provide a suitable rock cover over the tailings to prevent upward migration of acidic water into new topsoil introduced for the purposes of establishing vegetation.

Construct a suitable impervious soil cover with drainage control structures that will prevent scouring and ingress of water into the tailings.

Establish a vegetation cover over the area using reticulation, lime and other fertilisers.

3.1.3 Dysons Open Cut

Treat the water and release the total volume into the East Branch of the Finniss River.

Cover all tailings in the pit with Dysons overburden and compact the upper layer.

New topsoil and revegetation of this area was not considered as it may occur naturally on the overburden material.

3.1.4 Intermediate Open Cut -

The treatment of the water and the causes of the pollution were not fully understood at the time of 1978 'Summary' report. An innovative air infusion and lime addition plant was proposed to treat the water.

Treat the water to acceptable release standard using an air infusion system together with a lime addition plant.

Clean up the surrounding area so that the open cut can be used for aquatic recreation.

3.1.5 Whites Open Cut -

Connect Whites Open Cut to immediate Open Cut and treat the water during backfilling operations.

Dump the copper heap leach pile and some of Dysons overburden into Whites Open Cut (approximately $1.4 \times 10^6 m^3$). The displaced water would be treated prior to its entry into the Intermediate Open Cut and the remaining Whites water would be treated to raise the pH to a satisfactory level.

The D.H.C. recommended that the East Finniss River be diverted into Whites Open Cut rather than the Intermediate Open Cut, so that both open cuts could be recharged annually with fresh water, once both pits were connected.

3.1.6 Whites Overburden Heaps -

Reshape the overburden heaps to reduce the steep side slopes.

Shape the top of the heap to form drainage control channels.

Cover the reshaped stockpiles with an impervious soil cover suitably designed to prevent ingress of water into the stockpile and allow establishment of a vegetation cover over the entire area. The cover must also be designed to prevent erosion of the soil during the wet season.

Establish a vegetation cover over the whole area using reticulation during the dry season.

3.1.7 Whites North Overburden Heaps -

Remove large rocks to Whites Open Cut.

Reshape the stockpile in the same manner as Whites main heap, cover the stockpile with an impervious soil cap then revegetate the total area.

3.1.8 Intermediate Overburden Heap -

Carry out the same reshaping of the stockpile as for the Whites heaps, cover the stockpile with an impervious soil cap then revegetate the total area.

3.1.9 Dysons Overburden Heap -

Dysons heap was considered low in pyrite content, capable of supporting revegetation.

It was recommended in 'The Summary' to be used as a cover for the Intermediate Overburden Heap, but the D.H.C. modified the proposal and recommended its use for:

- Covering the tailings in Dysons Open Cut.
- Covering the copper heap leach pile after its placement in Whites Open Cut.
- Filling around the perimeter of Whites Open Cut to restrict some of the ground water movement through the pit.

Regrade, treat soil around Dysons and revegetate.

3.1.10 Acid and Sweetwater Dams -

A general cleanup of the river course to allow the creeks to flow along a more defined path thus allowing natural revegetation along the damaged river course.

The use of lime and other fertilizers was considered necessary without any additional topsoil to the area.

Some 36 hectares was included for rehabilitation in this area.

3.1.11 Other Areas -

Some general clean up creek beds, and surrounds to overburden heaps. It was planned to grade and mix in lime and fertilisers and reseed the affected areas.

The areas included for this work were:

Copper Creek

Surrounds to Whites Overburden

Surrounds to Dysons Overburden

Old Tailings Creek

It did not extend to all disturbed areas within the 200 hectare mine site.

3.1.12 Site Fence -

A 10 km perimeter fence was recommended to protect the revegetation works from animals grazing on newly established areas.

The fence had to be strong enough to resist buffaloes.

3.2 Results of 1982 Investigation Programme

Before any final adoption of 'strategy D' measures was possible, further investigations were required to provide answers to some problems not previously resolved.

The investigation programme carried out during March to May 1982 provided results for three major items:

3.2.1 Soils Investigation

The previous estimates were heavily qualified in respect to the availability of naturally occuring soils that would be buitable for construction of impervious overburden covers and soil suitable for vegetation growth.

3.2.2 Impervious Cover Design For Overburden Heaps

The quantity of soil types needed to cover reshaped overburden heaps was dependent on the proposed thickness of the cover to provide a 100 year life. A suitable engineered structure was necessary before final costs could be predicted.

3.2.3 Water Treatment Plant

A suitable treatment plant was designed to remove metal concentrations and raise the acidic properties to a more acceptable standard. In previous reports, insufficient testwork and technical data existed to adequately estimate the costs of a suitable plant and the consumption of reagents.

A summary of the findings have been included in the following sections. The complete technical details of the studies is contained in Volume 2 and 3 of this report.

3.2.1 Soils Investigations

A detailed soils investigations programme was undertaken to determine if suitable soil types existed close to the mine site that would provide the necessary engineering fill for impervious covers and top soil layers.

The results of the investigations are contained in Volume 2 of this report.

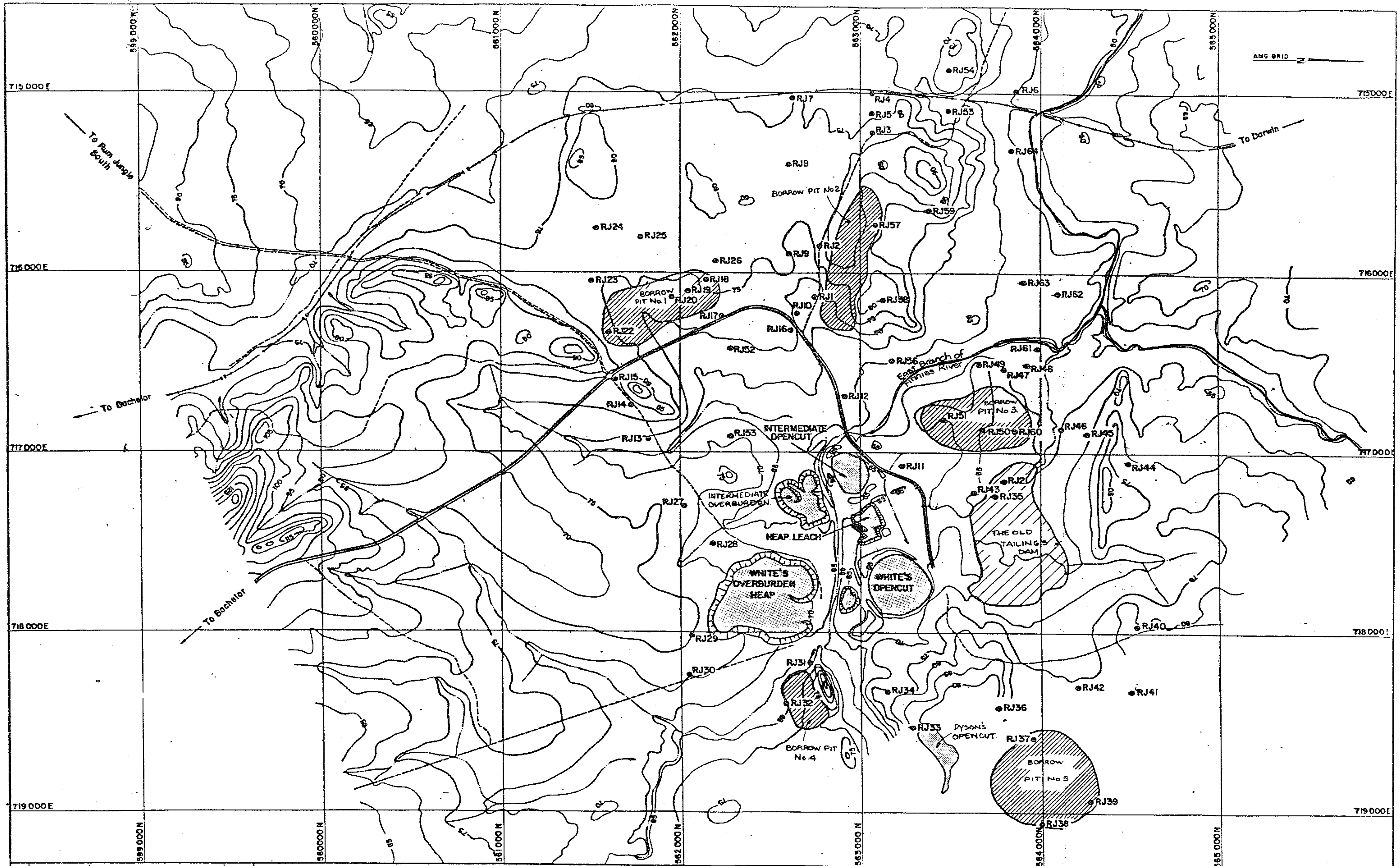
In summary of the investigations, suitable clayey - gravels, gravelly - sands and weathered granite was located within 2 km of the mine site.

The type of material found was suitable for the engineered layers proposed in this report. The only blending necessary will be the mixture of rip-rap and top soil in the top layer of the covers to aid erosion protection during vegetation regrowth.

The quantity of material located is in excess of the amounts required to complete the proposed works and the location of the pits will not cause harmful aesthetic aspects.

It is intended to recontour all pits on completion and assist with rapid revegetation of the pits.

A location map of the 5 prospective pits has been included in this summary.



No.	DATE	DESCRIPTION	APPD.
		REVISIONS	

NOTES:

- ● RJ — Test Pit.
- Sealed Road
- Unsealed Road
- Dirt Track

LEVEL DATUM AHD

REF. B.M.

AZIMUTH AMG

DRAWN:	RPD	DATE:	
TRACED:	M.W.	DATE:	MAY 1982
CHECKED:	G.B.A.	DATE:	MAY 1982

Meehan Burgess & Yeates
Consulting Engineers & Geologists

PASSED:

DATE:

RUM JUNGLE REHABILITATION PROJECT

LOCATION OF EXPLORATION

DRG. No. 2306-001

3.2.2 Impervious Cover Design For Overburden Heaps

As part of the investigation programme, preliminary design was completed, once the soil types had been identified, to determine the type of cover and thickness that would prevent infiltration of water into the heaps and remain impervious for 100 years.

The results of the cover design have been presented in Volume 2 of this report.

An extract of the main design criteria has been included in this section with typical drawings of the intended reshaping works, cover design and protection drainage system.

Design Criteria -

The principal criterion used in developing the designs mentioned above was that the Rum Jungle Rehabilitation works should provide, within relatively fixed budget limits, structures which will maintain their integrity for a period in excess of 100 years whilst at the same time provide protection against the generation of contaminants from the waste heaps which they are intended to protect.

Following on from this criterion or principal objective of the design, a number of sub-criteria was identified, these being:

- Maximum usage to be made of existing natural materials.

- Imported materials required to provide selected covering layers to be obtained from borrow areas within a radius of no more than 10 km around the Project Area.

- The development of borrow areas and the construction of the rehabilitation structures is not to significantly damage the environment which already exists, and materials used should be relatively inert, from the point of view of contaminant generation.

- The design of stable covers should show generally similar profiles and stability to the naturally developed soil profiles in the area so stability may be provided over the minimum life of 100 years.

- The covers wherever possible should allow for natural revegetation to occur by the incorporation of not only an erosion protective layer but also a layer of topsoil or other material which will be suitable for the maintenance of vegetative growth.

The location and typical topographic features of the White's and Intermediate Overburden Heaps are shown on preliminary drawings included.

Stabilisation of the Outer Slopes of the Heaps -

From observations made of the White's Overburden Heap and the Intermediate Overburden Heap, it is apparent that one of the major sources of contamination results from the infiltration of rainwaters into the uncompacted edges of the heap only to re-appear at the toe of the heap as springs carrying a significant contaminant load. Thus in developing the design of the covers on the slopes of White's Overburden and Intermediate Overburden, consideration has been given to minimising the amount of infiltration into the slopes.

The control over infiltration is:

- The provision of an "interception and surface store" in the topsoil and rockfill outer layer. The interception and surface store will eventually comprise vegetation and topsoil pockets and should provide storage for the initial 20 to 30 mm of rainfall during any single storm on to the heaps. In the existing heaps, this rainfall penetrates rapidly through the outer layer because of the rough and porous nature of the layer and progresses into the lower layers where it is then unavailable for evaporative loss through evapo-transpiration. By providing the interception and surface store with a capacity of 20 to 30 mm infiltration and by maintaining 3:1 slopes on the edges which will provide for rapid rainfall runoff during rainstorms in excess of 30 mm, the extent of infiltration into the heap will be minimised and as a consequence, the amount of contaminants generated will be considerably reduced from the existing levels.

- The provision of a gravelly clay layer 300 mm thick having low permeability.

As part of the rehabilitation programme, the outer slopes of the waste dump piles of White's Overburden and the Intermediate Overburden Heaps will be stabilised by the flattening of existing batter slopes and the development of drainage structures within the top surface of the piles.

The work involved in the outer slopes will comprise:

- The flattening of batters around the perimeters of the pile to slopes not exceeding 3 horizontal to 1 vertical

- The development of stable drainage lines protected from erosion

- The development of a simple layered cover which will inhibit rainfall infiltration into the heaps and provide a site for revegetation to commence.

A typical cross section through a stabilised slope is shown on Figure D17. The approach with respect to the stabilisation of the slopes and the subsequent cover for each of the waste dumps is essentially the same.

For both the White's Overburden Heap and the Intermediate Overburden Heap batter flattening will be carried out. This will involve the establishment of cut to fill slopes of 3 horizontal to 1 vertical with berms 5 metres wide at 9 metre vertical intervals. These berms would be sloping at a similar slope to the natural ground surface rather than horizontal. There will be regular turnouts on the berms to ensure that water flow into the heaps is minimised and led off the heap into rip-rap lined drainage channels at the toe of the heaps as quickly as possible.

On the edges of the heaps where cutting and filling has been carried out, the outer 450 mm layer of the reshaped surface will be compacted by vibratory roller to a granular surface. The aim of this layer is to provide a "filter" layer for the overlying gravelly clay layer, to reduce the tendency for the clay soils to wash into voids of the underlying waste rock.

The gravelly clay layer overlying the compacted outer surface of the waste dump will have an initial thickness of 300 mm when compacted and will be overlain by 450 mm of compacted gravel or rockfill with topsoil infill.

The batter slopes of 3 horizontal to 1 vertical are considered to be the maximum possible to allow compaction equipment to move without special handling procedures.

Stabilisation of the Top Surface of the Heaps -

The designs have addressed a slightly different condition for the top surface of the overburden heaps. For the top surface of the overburden heaps, it is essential that any rainfall runs off rapidly into well defined channels and does not have the possibility to pond and thus infiltrate the heap.

In contrast to the sides of the heap however, the surface slopes are relatively smooth and there has already been a considerable degree of compaction due to the passage of normal mining equipment during the development of the heaps.

Thus, the designs developed to cater for the rehabilitation of the overburden heaps had to take into account a limited amount of recompaction where necessary of the upper surface to ensure that a granular tight rockfill surface existed and that this was overlain by a layer of clay, earth-rockfill and topsoil materials similar to the sides of the heap.

Thus, the designs have allowed for the compaction of the upper surface to establish this granular smooth base before placement of the capping comprising a gravelly clay layer 300 mm thick. The uppermost surface of the cover will be formed by a layer of ripped earth-rockfill material 200 mm thick. This upper layer would not be compacted other than by bulldozer tracking and construction equipment and the topsoil would be loosely spread into the material.

To encourage interception of water and therefore minimise the amount of main infiltration into the pile, a vegetative cover will be provided with a capacity similar to that of the side slopes (about 20 to 30 mm of the initial rainfall). The underlying gravelly clay layer will have a relatively low permeability and thus the infiltration capacity will be rapidly reached during heavy rainfalls and overland flow will occur into the controlled drainage lines. Thus, for light rainfalls, infiltrating water will be trapped in the surface soils and vegetation whilst for heavy rainfall, the water would runoff into the drains.

Cover design for Dyson's Open Cut -

As part of the overall rehabilitation for the Rum Jungle Project Area, the Dyson's Open Cut would be backfilled by using initially the heap leach pile followed by the tailings material. Once these materials are in place, waste rock will be transferred from the Dyson's heap to cover the tailings and when the overall designed shape has been achieved, then a final cover will be placed.

For the design, it has been assumed that as part of the selection process for the materials on the Dyson's heap, the most contaminated portions of the waste and those zones which have the greatest potential to generate contaminants will be removed first. The material would be progressively dumped into the Dyson's Open Cut by end dumping techniques with the overall height of dump restricted to 9 m to ensure that unacceptable differential settlements do not occur. It is not intended that the material be compacted other than by the passage of construction equipment, because of the increased cost of such an operation.

As the material is dumped into the open cut, it will be placed to pre-determined survey lines to ensure that a simple mounded profile is developed. The shape of the heap as shown on the cross sections, Figure D18, will provide a stable heap which will ensure rapid runoff of waters rather than infiltration into the dumped rock materials.

The upper 450 mm, i.e. the last lift of dumped rockfill materials during dumping, will be compacted to establish a granular, relatively smooth surface which will act as a "filter bed" on the upper surface of the heap. This compaction will be achieved by a smooth drum vibratory roller.

The actual cover design and surface treatment above this will comprise:

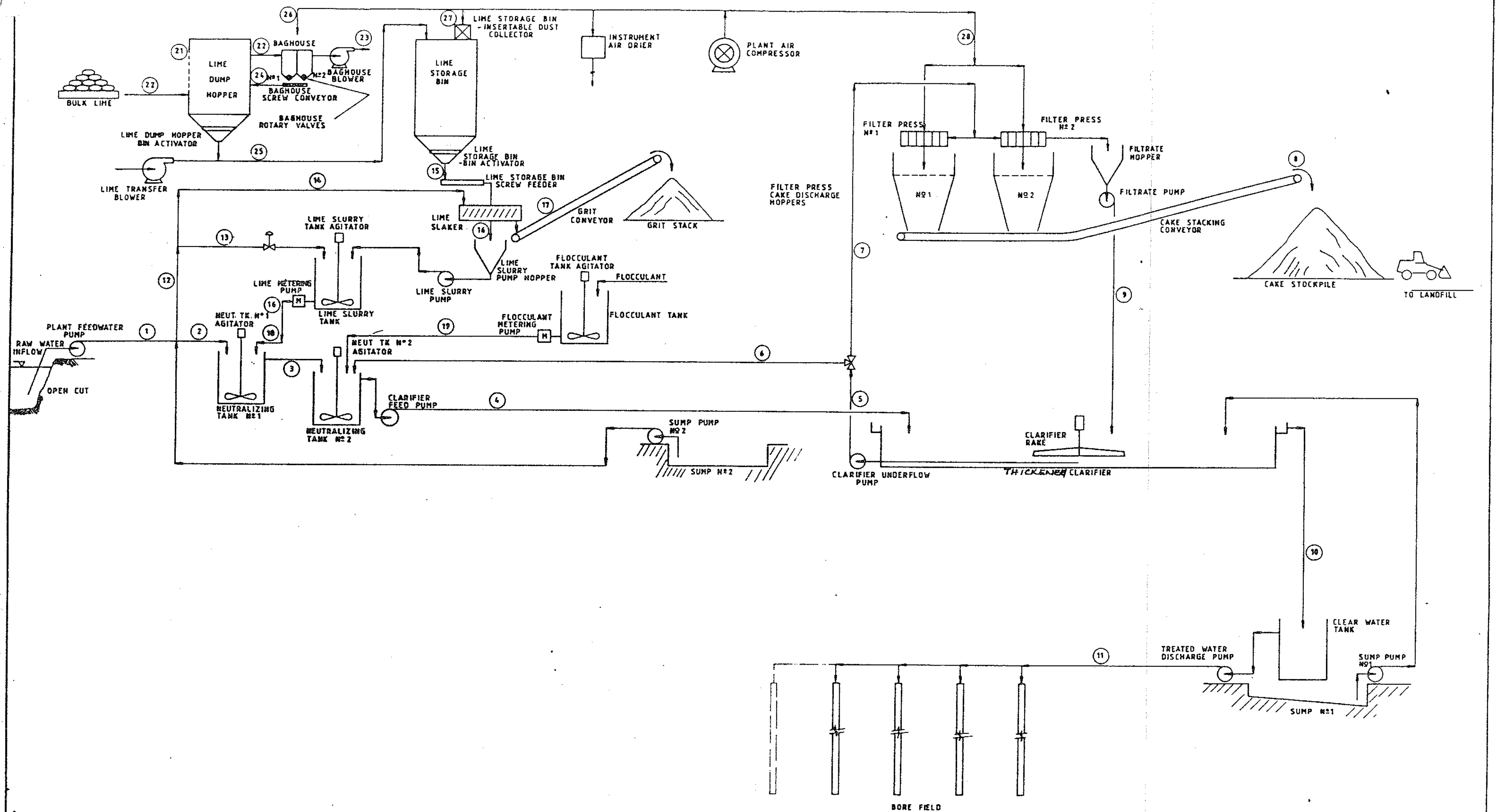
- A lateritic gravelly clay layer (300 mm compacted thickness) whose purpose is to minimise infiltration into the heap. The objective of the clay is to provide sufficient retention for infiltrating waters so that during rainfalls of 20 to 30 mm, the water remains perched in the clay layer rather than infiltration. Disposal of storms of greater than 20 to 30 mm will be by saturation of the upper layer and surface runoff into rip-rap lined drains around the perimeter.

- A layer 300 mm thick of fine rock rip-rap material infilled with topsoil; this layer will be compacted only by the passage of bulldozers and spreading equipment and will contain sufficient voids into which the topsoil will infiltrate and establish a bed for subsequent growth.

On completion, the upper surface of Dyson's heap will slope at about 1 vertical to 8 horizontal, blending into the natural surface on either side of the heap with a rip-rap lined drain on the uphill side.

The objective of the final treatment of the Dysons heap is to provide a stable revegetated surface which will not be subject to erosion or scouring. The surface will be revegetated to ensure a maximum interception of light rainfalls and evapo-transpiration loss rather than permitting infiltration into the heap. It is expected that the first 20 to 30 mm of rainfall will be absorbed by the upper layers and that which penetrates to the underlying rockfill will be insufficient to cause significant contaminant generation in the rock materials which are used for filling the heap.

The first materials to be placed into Dyson's Open Cut will be the heap leach material and the tailings from the Old Tailings dam. The majority of this material which has a high potential for contaminant generation will be placed in the bottom of the pit so that any small amount of rainwaters which penetrate through the cover and into the underlying rock materials will tend to cause oxidation in the more inert portion of the rock from Dysons heap before penetrating to the level of the tailings and heap leach material.



FLOWLINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Av SOLIDS FLOW tph			1·253	1·6067	1·7684	0·3537	1·4147	1·4147							1·0	1·253	0·068	1·253		30		5		5	30			
Av LIQUIDS FLOW m^3/hr	420	396·1930	420	442·2762	136·7909	27·276	109·5147	1·4147	108·10	418·6273	418·7890	23·8070	15·036	8·7710		8·7710		23·8070			28·6×10^3		28·6×10^3					
Av TOTAL FLOW tph		420	421·253	448·9249	138·5593	27·63	110·9294	2·8294	108·10	418·6273	418·7890	23·8070	15·036	8·7710	1·0	10·0240	0·068	25·06	0·042							0·0053	0·0046	0·0004
PEAK TOTAL FLOW tph							140	5·6588		418·6273	418·7890	47·6140	30·072	17·5420	2·0		0·136	50·0	0·084	50		8		8	50			
PEAK FLOW TIME hr/day							6–8	24		24	24	24	24	24	24	24	24	24	24	2		2		2	2			
PRESSURE kPa	98			98	834				50		981															620	45	48
pH	2·8	2·8								8·5 – 9·0	8·0 – 8·5					>10		>10	APPROX 7									

No.	BY	DATE	REFERENCE DRAWINGS

MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

2/3 WHITEFIELD ST, DARWIN

No.	BY	DATE	REVISION	APPROV

	date	sign
CLIENT APPR.		
PROJECT APPR.		
DESIGN APPR.	10/5/82	
CHECKED	18-5-82	
DRAWN	14-5-82	

PLANT NORTH U.O.N.

CLIENT: THE NORTHERN TERRITORY OF AUSTRALIA DEPARTMENT OF TRANSPORT & WORKS

TITLE: RUM JUNGLE REHABILITATION PROJECT WATER TREATMENT PLANT PRELIMINARY SCHEMATIC FLOW SHEET

SIZE: B1 SCALE: N.T.S.

REV No:

DRAWING No: RJR-00/F-001

RUM JUNGLE REHABILITATION

ENGINEERING REPORT

MAY 1982

VOLUME 1

PREPARED BY

MINING & PROCESS ENGINEERING
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Material requirements in terms of volumes are summarised on Table 1; material thicknesses and properties are given on Table 2.

Design of Drainage Structures -

For the rehabilitation works, there will be essentially two types of drainage structures, these being:

- Collector drains on the surface of the overburden heaps
- Catch drains at the foot of the overburden heaps.

Collector Drains on the Surface -

The collector drains on the surface of the heap will have gradients of between 1 and 10%. The required capacity of the drains increases with decreasing elevation as additional catch drains, formed in a dendritic pattern, on the top of the heap, discharge their waters.

The design adopted for the main collector drains, therefore, varies along its length. In the upper part of the catchment where the collecting catchment is less than about 2 ha, it will be sufficient to excavate and form definite drainage lines on the existing heap and to carry out recompaction at the base of the drains to enable runoff of the stormwaters.

With increasing distance below the top of the heap, the capacity of the drains will be increased and, in order to minimise the effects of erosion and scour, a series of drop structures formed by gabion retaining bunds will be constructed. A typical design of the gabion bund and drop structures is shown on Figure D19. A typical successful use of gabions in a similar environment is shown on Figure D20. The selection of gabions has been adopted because of the need to control the cost of structures and the long term erosion requirements.

Initially, the bunds will be free standing and water which infiltrates behind the bund will be temporarily retained, thereby minimising erosional velocities down the channel. The secondary purpose of the gabion bunds during the establishment of vegetation on the heap, will be to provide retention for erosion products so that the risk of carrying suspended sediment into the Finniss River is minimised. A further reason for adopting these gabion bunds is that they can continue to operate even when complete siltation has occurred behind them. The wire reinforcement on the bunds will be coated with ultra violet resistent PVC to increase their longevity.

In addition, by providing a silt trap in order to collect any erosional products off the surface of the heap, the bunds will tend to revegetate naturally and thereby provide a vegetation or tree lined water course in the centre of the heap.

If, during the 100 year life of the erosion protection measures, the wire forming the gabion bunds should corrode, it is expected that the remaining pile of rocks and revegetated channel will be sufficient to retain sediment.

Other advantages of using gabions in the design are:

- Flexibility

  The use of gabions will enable the walls to be constructed even on reformed parts of the stockpile without undue need for foundation preparation. The gabions can, without loss of structural efficiency, deform or bend rather than crack or collapse under alternating tension or compression or in the event of ground subsidence.

- Permeability

  Gabions exhibit a high degree of permeability which will allow not only collection of silt but will act in effect as a series of retardation basins which will nevertheless not pond the water and allow it to penetrate into the centre of the overburden heaps.

- Costs

  The cost of construction of gabions and their transport to the site is considerably cheaper than other measures needed to control erosion in the centre of the gully, such as concrete.

- <u>Width of Drainage Channel</u>

  By using gabions rather than excavated channels with rock retaining embankments, the width of the central drainage channels can be minimised and thereby allow greater vegetation cover in the main channel.

Catch Drains at the Foot of the Overburden Heaps

A significant source of pollution and environmental degradation occurs around the perimeter of the overburden heaps where the emerging acidic seepage water has led to the destruction of root systems of the vegetation which formerly stabilised the creek channels and maintain surface flows in well defined paths. With destruction of the root structure this stabilising effect is no longer present and the channels have widened to the extent that large areas are now devoid of vegetation. To exert control over this problem, a series of catch drains at the toe of each of the rehabilitated slopes will be constructed which will collect the runoff from the slopes as well as any residual seepage waters and lead it through rip-rap lined channels into the main water courses where the potential for degradation will be lessened.

A typical section through such a lined catch drain is shwon on Figure D17. The stability of these drains will be provided by their rocky nature and their degree of entrenchment below the surrounding ground surface. The capacity of the catch drains will be sufficient to ensure that overland flow of waters which either runoff from the waste dump or flow from it in the form of residual seepage does not occur. This will restrict the area where runoff waters and seepage waters from the waste dumps occurs to the immediate vicinity of the drainage channels, thus permitting revegetation of the previously damaged areas to take place naturally.

MATERIAL	LOCATION			TOTAL (m^3)
	WHITE'S OVERBURDEN (m^3)	INTERMEDIATE OVERBURDEN (m^3)	DYSON'S HEAP (m^3)	
Compacted Gravelly CLAY	69,000	19,000	18,000	106,000
Loosely Compacted Lateritic GRAVEL or ROCKFILL with topsoil infill	57,000	17,000	-	74,000
Fine RIP RAP with topsoil	-	-	18,000	18,000
Fine RIP RAP for drains	1,000	500	1,200	2,700

RUM JUNGLE REHABILITATION PROJECT

TABLE 1 - QUANTITIES OF REQUIRED MATERIALS

NOTE: Dysons reshaped heap added after report table was completed. See Volume 2 for amended table.

Location	Cover Material	Thickness mm	Slope H:V	Compaction	Material Type	Properties P.I.	L.L.
Dyson's Open Cut	Topsoil/Rip-Rap	300	Varies	Construction Equipment	Ripped Sandstone	N/A	N/A
	Gravelly Clay	300	(Max) 4:1	90% Standard	Lateritic Gravelly Clay	30	45
	Waste Rock Top Surface	450		2 passes Vibratory Roller		N/A	N/A
White's Overburden	Topsoil/Rip-Rap	450	3:1	Construction Equipment	Ripped blasted sandstone, inert waste	N/A	N/A
Intermediate Overburden	Gravelly Clay	300	3:1	90% Standard	Lateritic Gravelly Clay	25	40
Outer Edges	Waste Rock Top Surface	450		2 passes Vibratory Roller		N/A	N/A
White's Overburden	Topsoil/Rip-Rap	200	Varies Maximum	Construction Equipment	Lateritic gravel Ripped Granite	10	25
Intermediate Overburden	Gravelly Clay	300	8:1	90% Standard	Lateritic clay Weathered phyllite	25	40
Top Surface	Waste Rock Top Surface	450		2 passes Vibratory Roller		N/A	N/A

TABLE 2 - RUM JUNGLE REHABILITATION PROJECT - COVER DESIGN

NOTE: Dysons reshaped heap added after report table was completed. See Volume 2 for amended table.

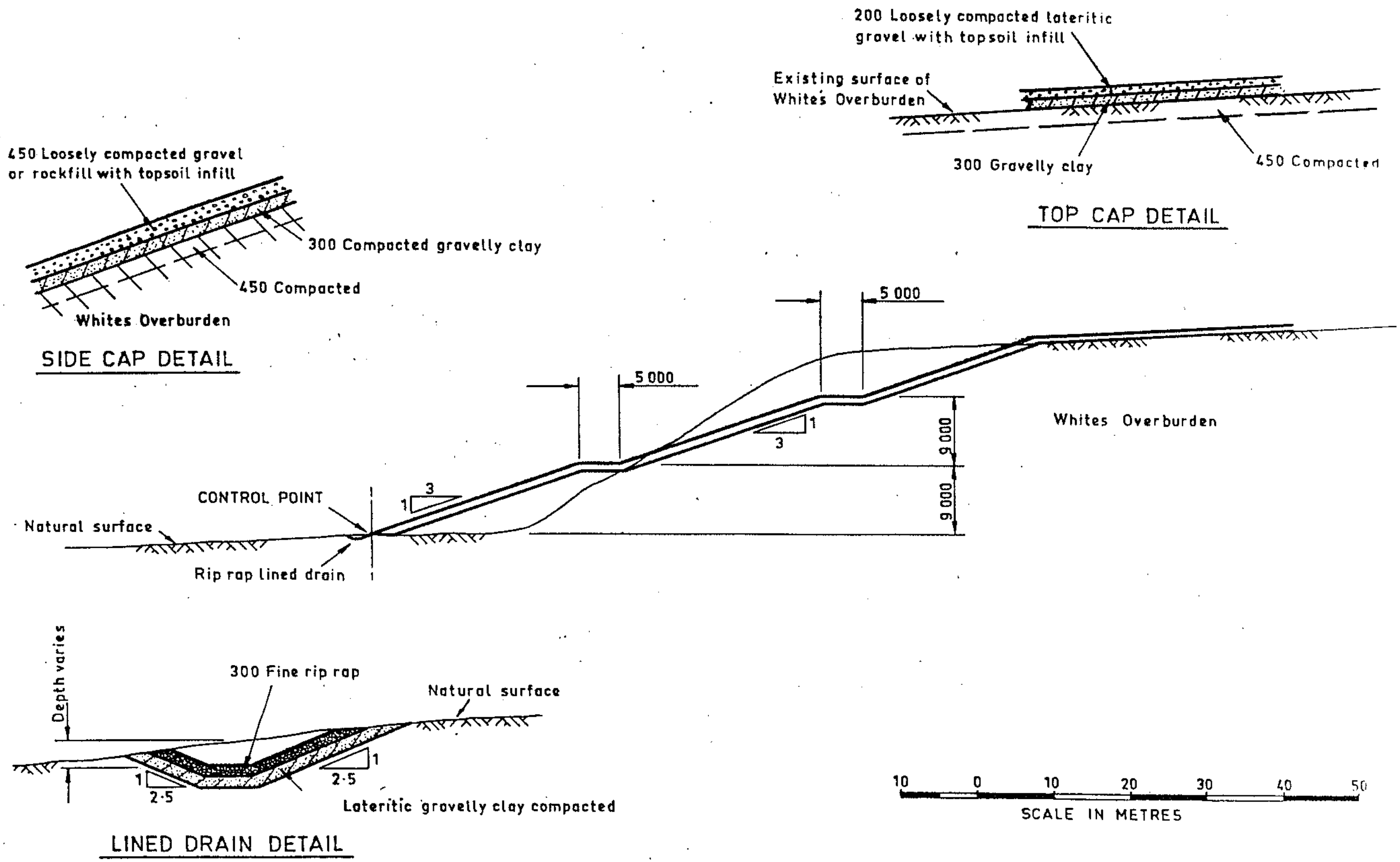


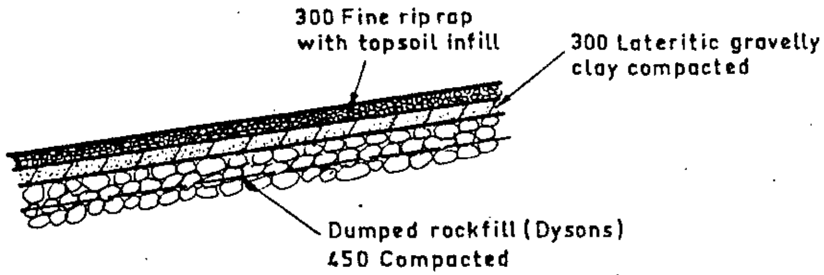
FIGURE D17

Revisions	Date

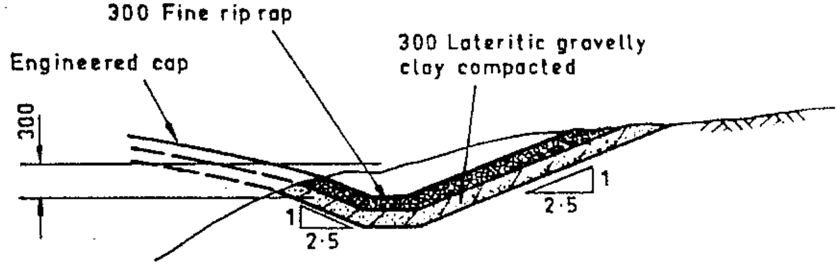
TYPICAL SECTION
TREATMENT OF WHITES OVERBURDEN
AND INTERMEDIATE OVERBURDEN

Meehan Burgess & Yeates

DRG.N°. 2306-003



CAP DETAIL



LINED DRAIN DETAIL

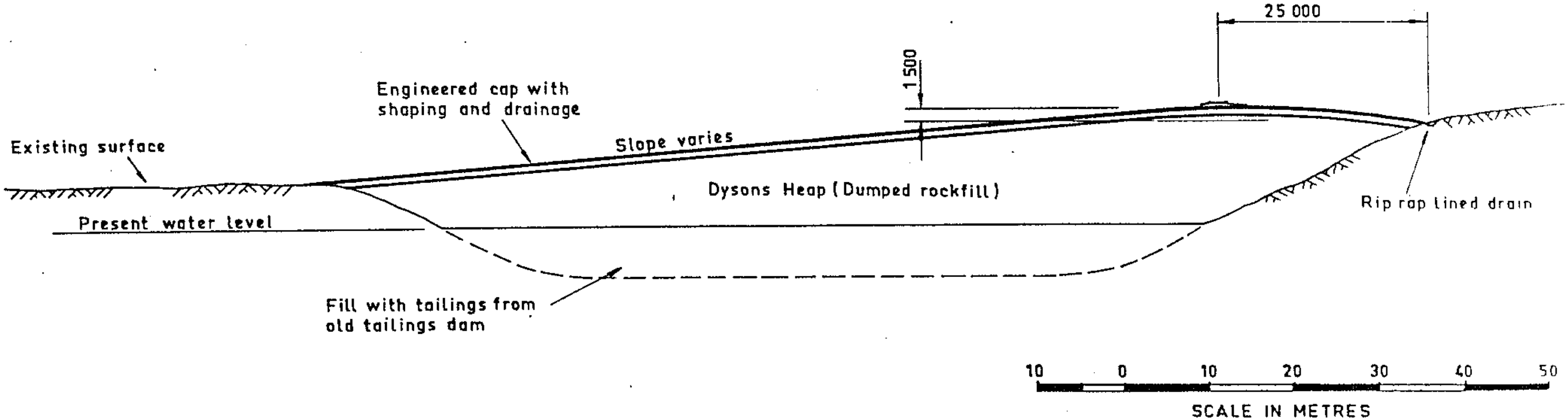
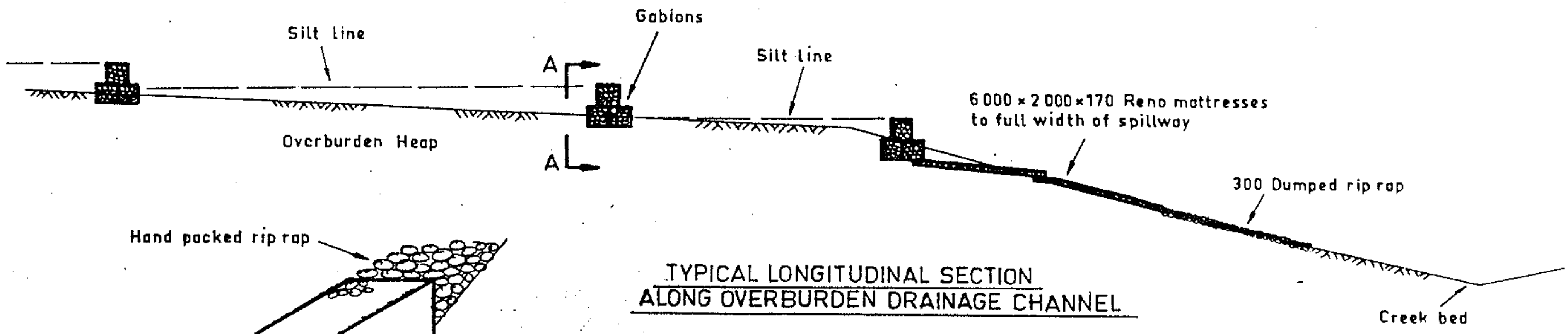
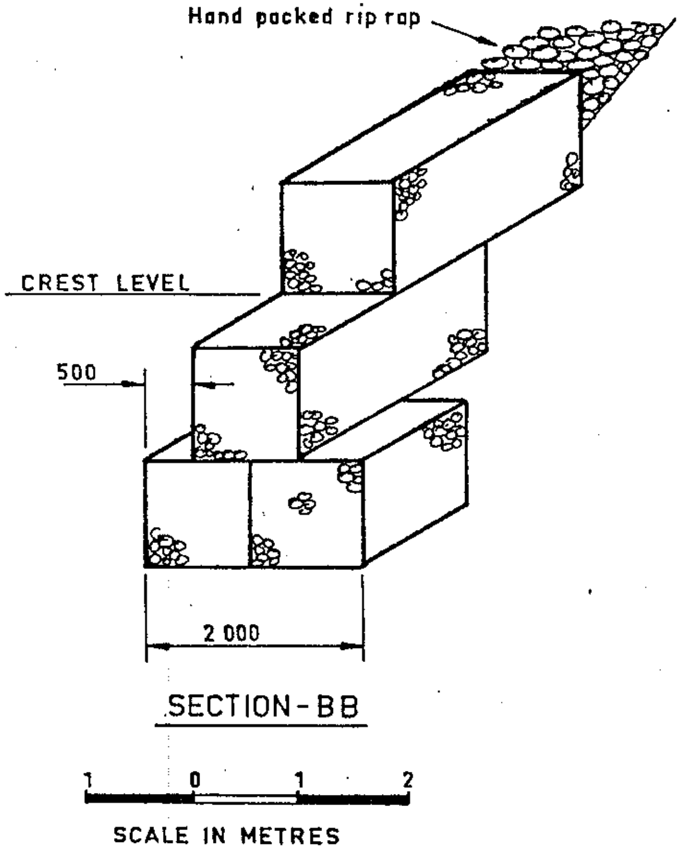


FIGURE D18

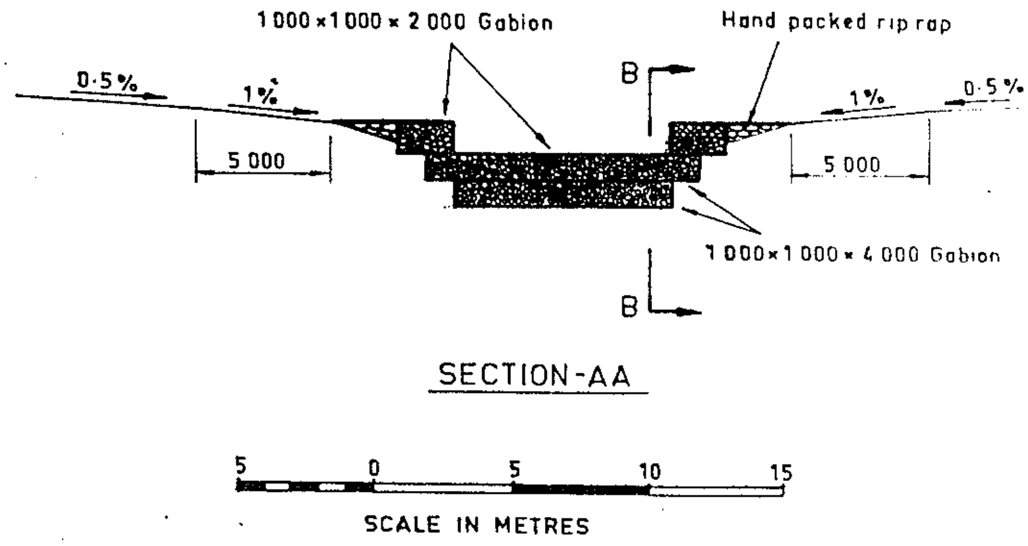
Revisions	Date		
		TYPICAL SECTION TREATMENT OF DYSON'S HEAP	
		Meehan Burgess & Yeates	DRG N°. 2306 - 002



TYPICAL LONGITUDINAL SECTION
ALONG OVERBURDEN DRAINAGE CHANNEL



SECTION - BB



SECTION - AA

FIGURE D19

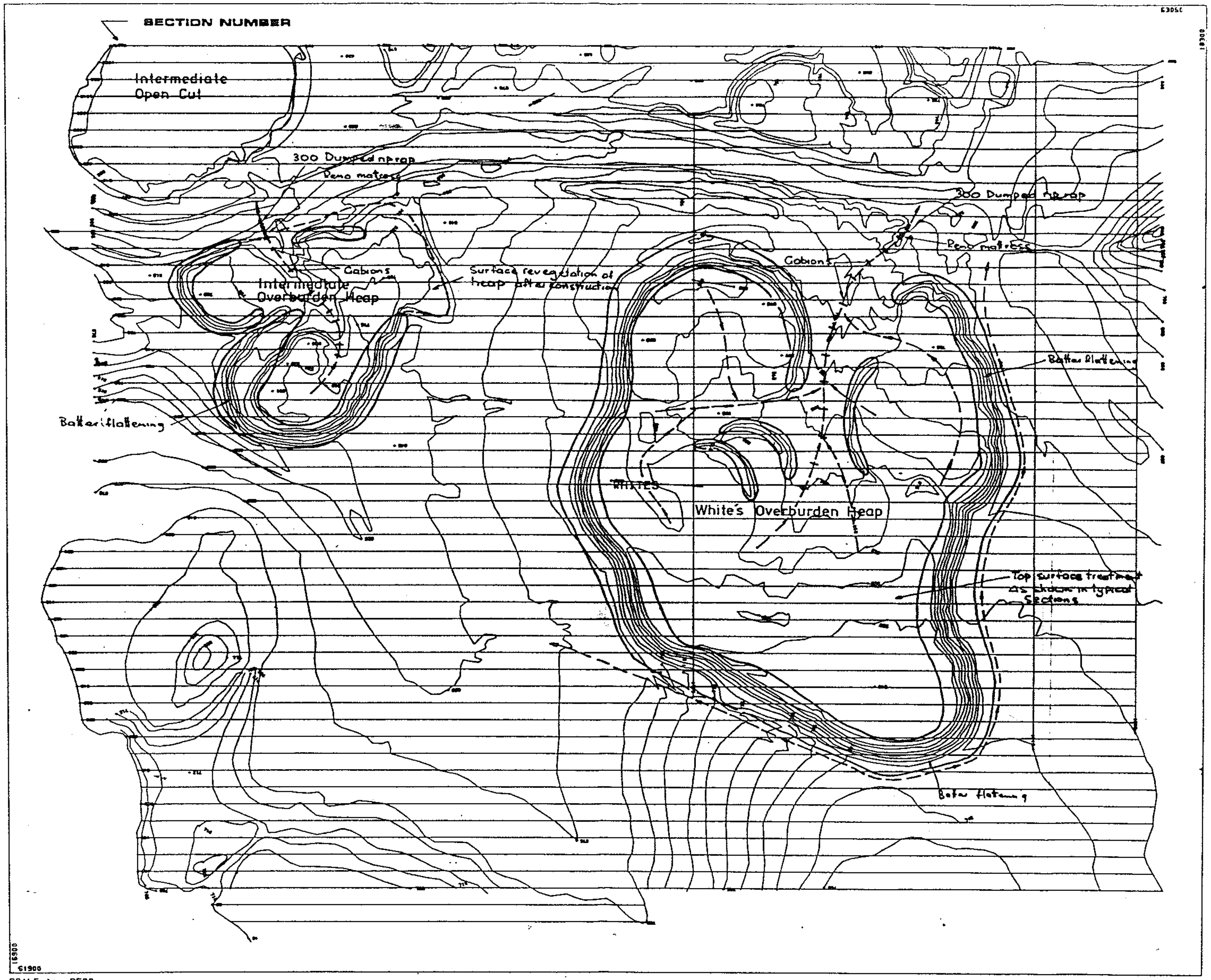
	Date
Revisions	

TYPICAL SECTIONS
OVERBURDEN DRAINAGE CHANNEL DETAILS

Meehan Burgess & Yeates | DRG. Nº. 2306-006

A series of small check dams preventing erosion in a gully.

Figure D20



SCALE 1: 2500

No	BY	DATE	REFERENCE DRAWINGS

MINING & PROCESS ENGINEERING SERVICES PTY. LTD.

No	BY	DATE	REVISION	APPROV

CLIENT APPR
PROJECT APPR
DESIGN APPR
CHECKED
DRAWN

PLANT NORTH

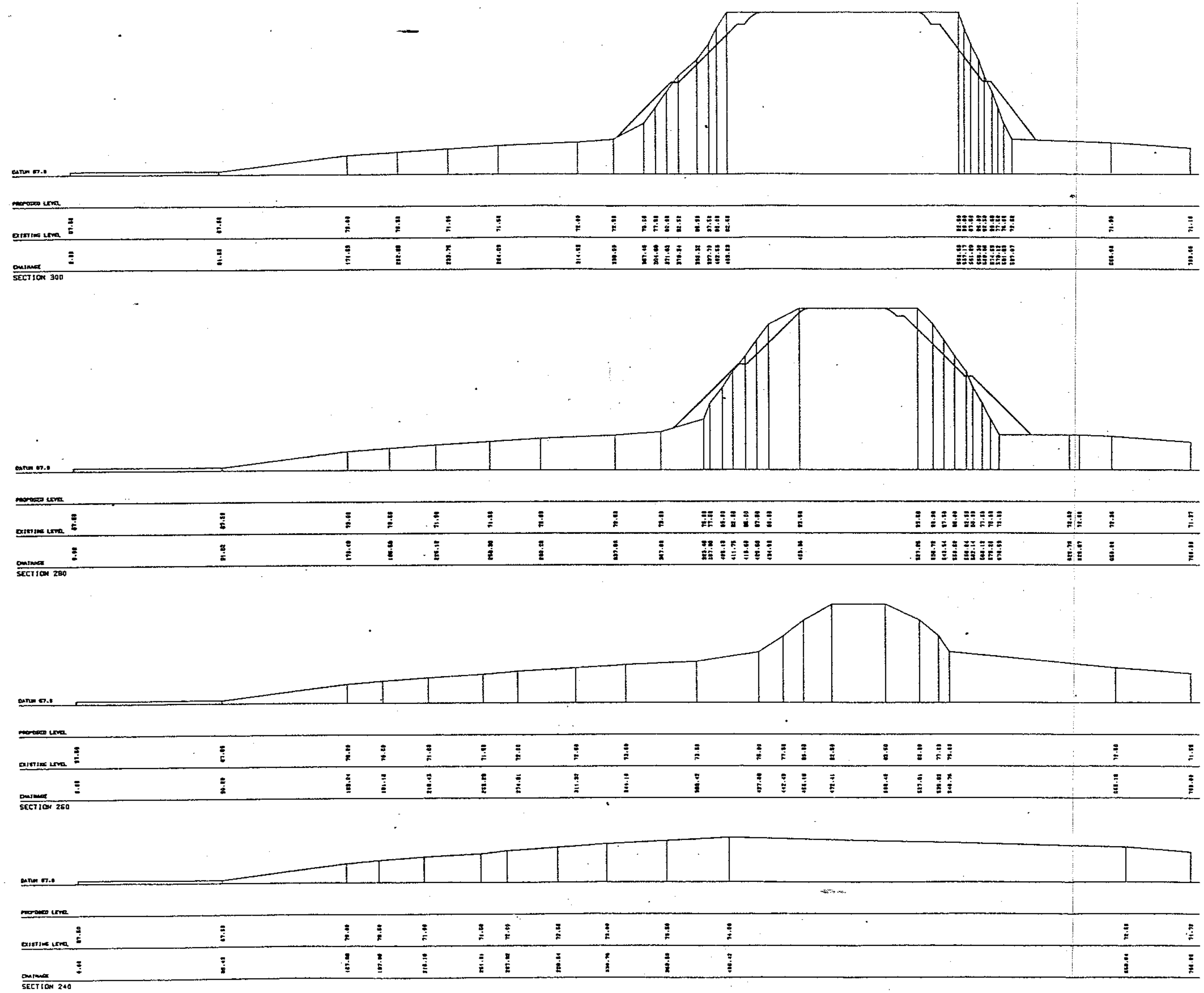
CLIENT: DEPT. OF TRANSPORT & WORKS (N.T.)

SIZE | SCALE: 1:2500

TITLE: RUM JUNGLE REHABILITATION
KEY PLAN - WHITE'S / INTERMEDIATE

REV No

DRAWING No: TW - RJ - 002



Meehan Burgess & Yeates
Consulting Engineers & Geologists

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PLANT GRID NORTH

CLIENT	N.T. DEPT. OF TRANSPORT & WORKS
SIZE	A0
SCALE	HORZ 1:1000 VERT 1:200
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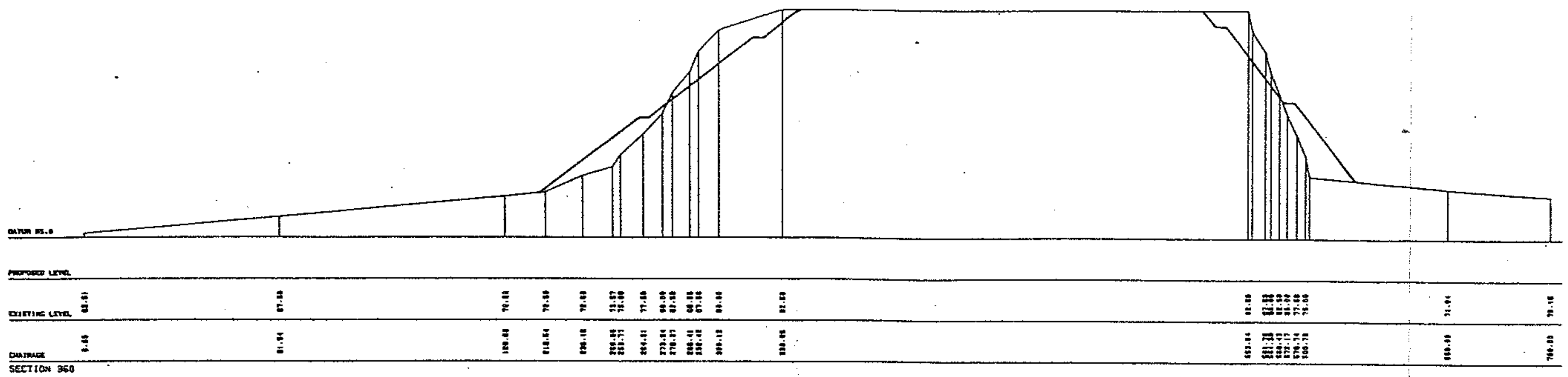
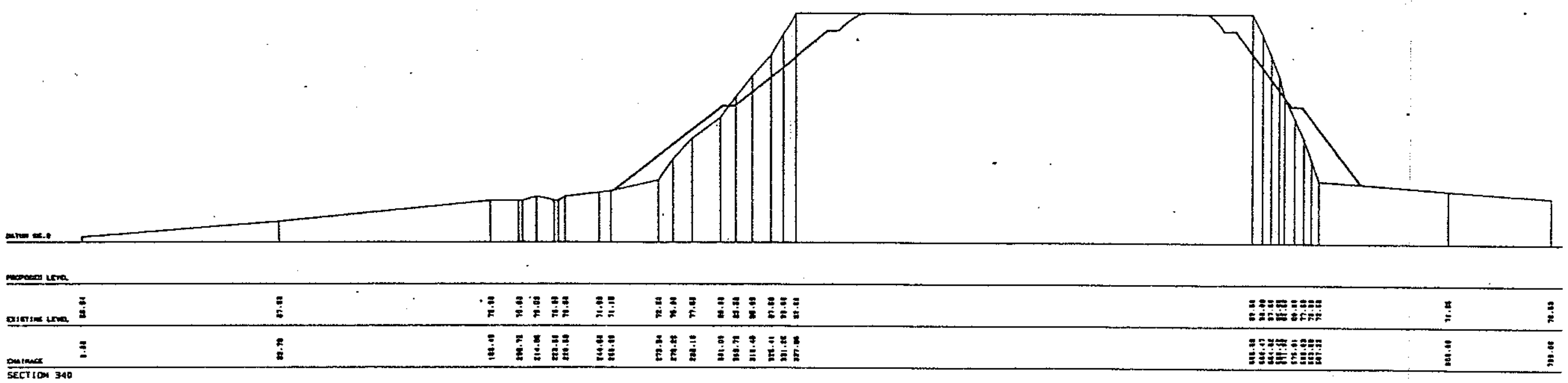
DRAWING No.	T.W.- RJ - 004



SECTION 360



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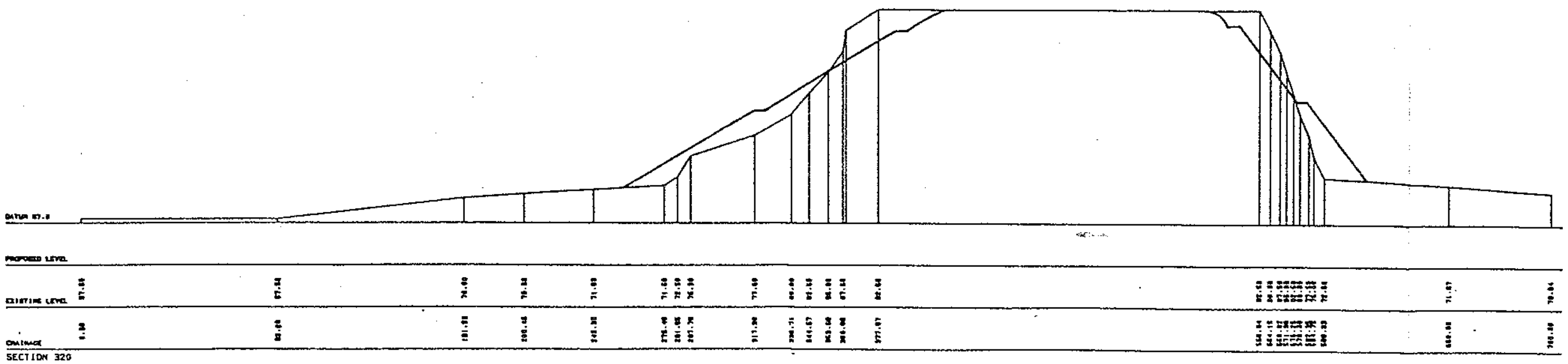

SECTION 320

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WHITE'S

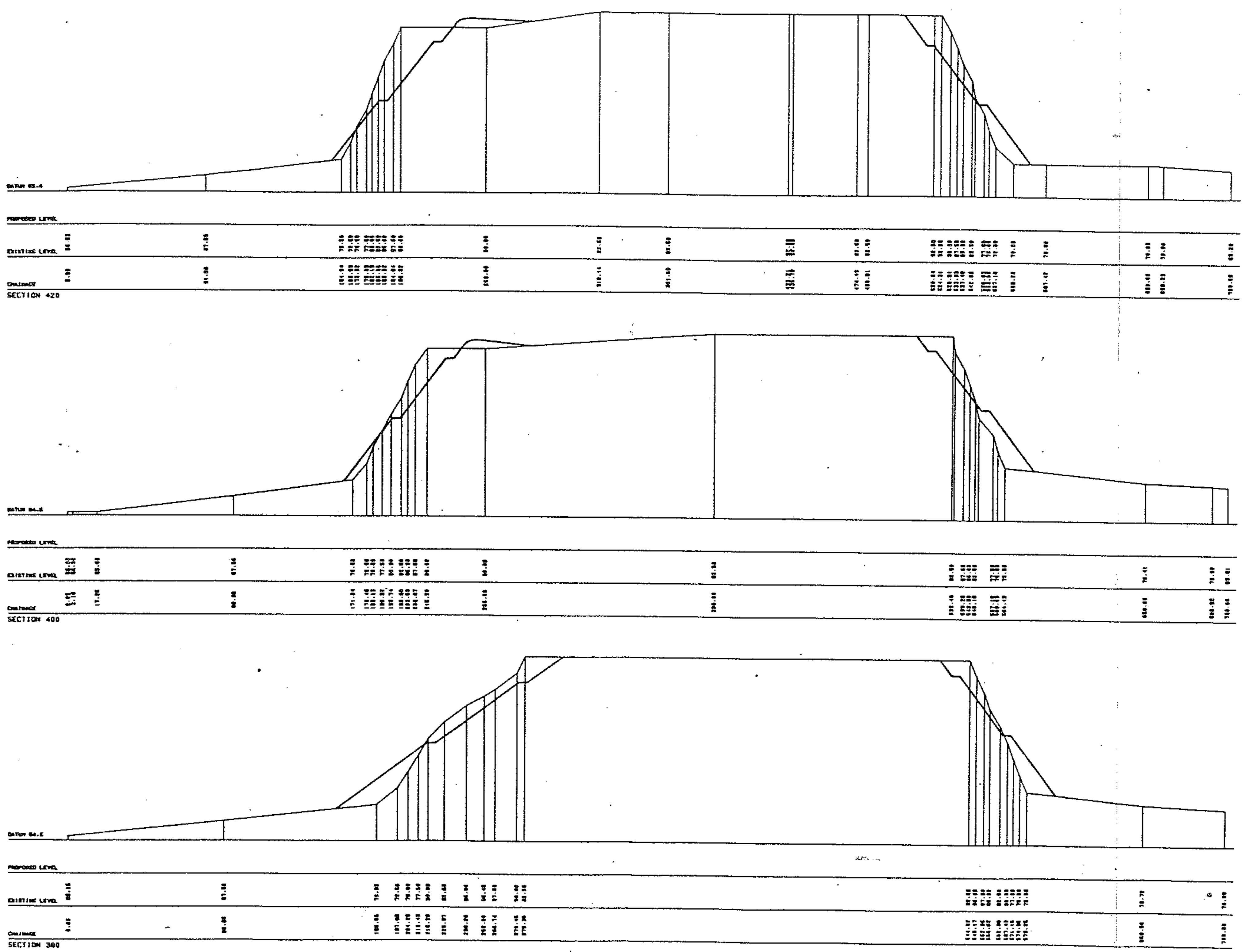
N.T. DEPARTMENT OF TRANSPORT & WORKS

A0

RUM JUNGLE REHABILITATION

WHITE'S OVERBURDEN - TYPICAL SECTIONS

TW - RJ - 005



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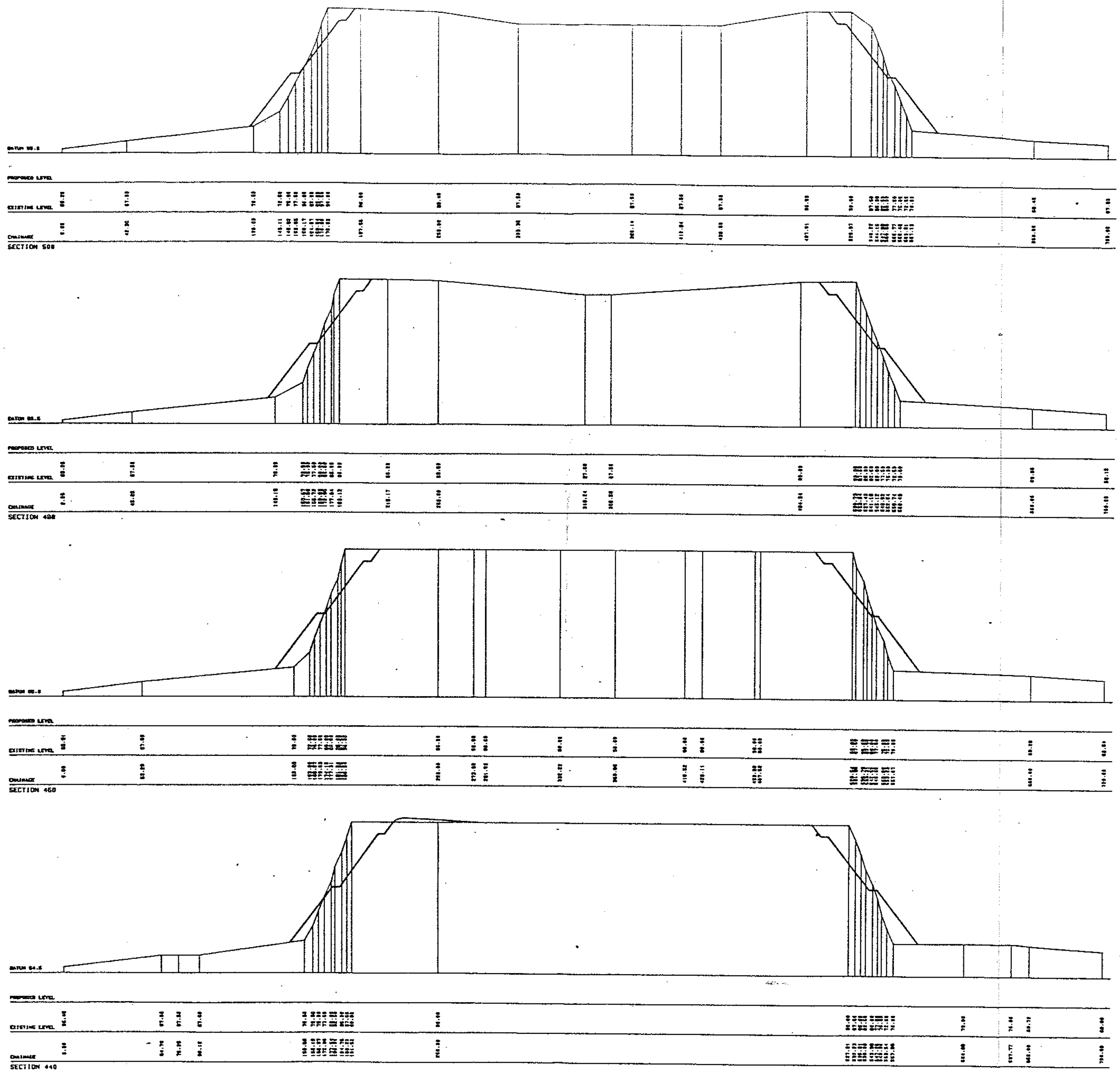
WHITE'S

CLIENT: N.T. DEPT. OF TRANSPORT & WORKS

SIZE: A0

TITLE: RUM JUNGLE REHABILITATION
WHITE'S OVERBURDEN - TYPICAL SECTIONS

DRAWING No.: T.W. - RJ - 006



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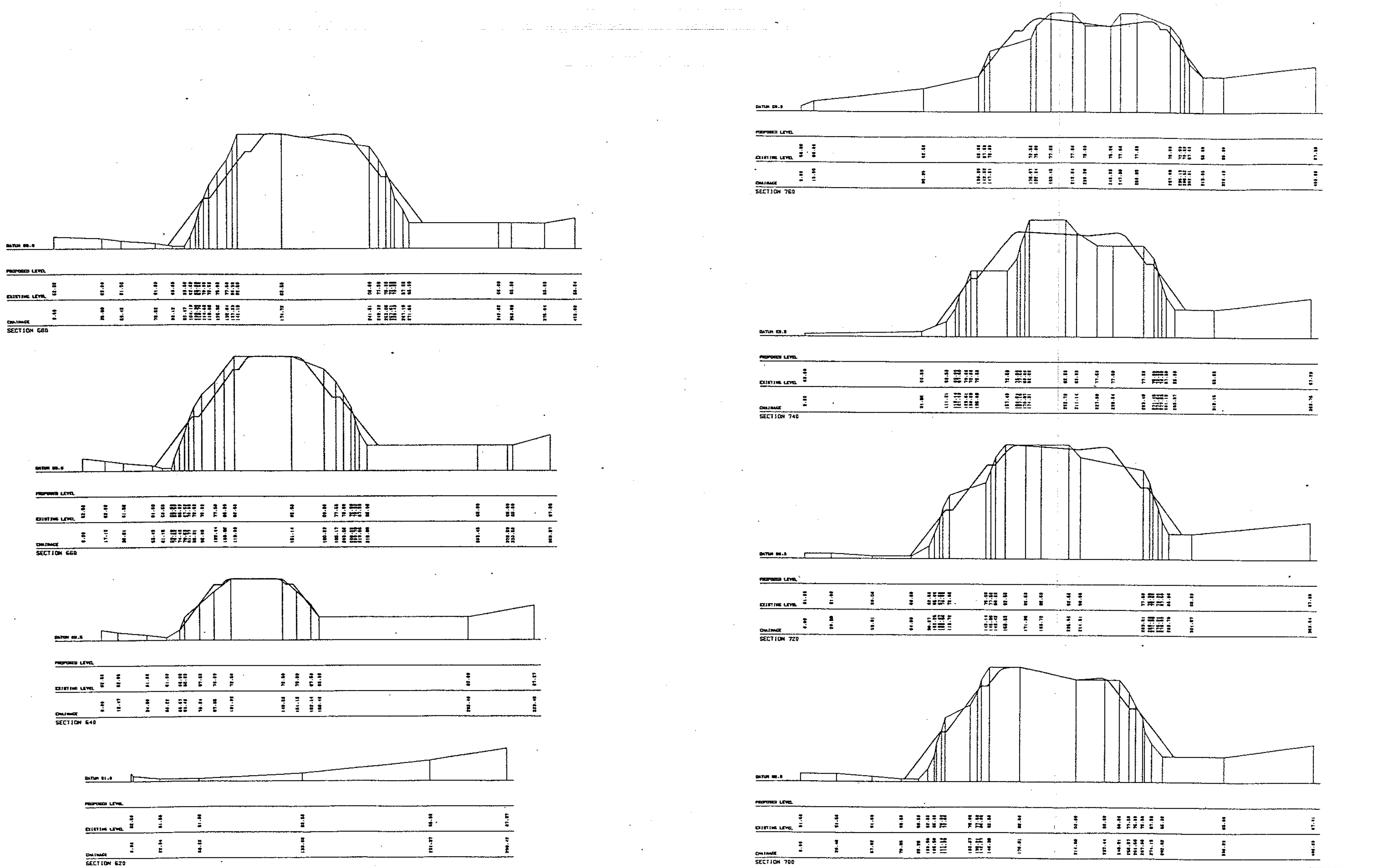
WHITE'S

CLIENT: N.T. DEPT. OF TRANSPORT & WORKS

SIZE: A0

TITLE: RUM JUNGLE REHABILITATION
WHITE'S OVERBURDEN - TYPICAL SECTIONS

DRAWING No.: TW-RJ-007



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PLANT GRID NORTH

CLIENT: N.T. DEPT. OF TRANSPORT & WORKS

SIZE: A0

SCALE: HORIZ 1:1000 VERT 1:200

TITLE: RUM JUNGLE REHABILITATION
INTERMEDIATE - TYPICAL SECTIONS

DRAWING No. TW-RJ-013

3.2.3 Water Treatment Plant

Two options were proposed in previous reports:

(a) Controlled water treatment through a plant designed to treat water at a nominated rate before release to the East Finniss River.

(b) Insitu treatment of the open cut pit water using an air infusion and lime addition plant in the open cut pits.

Only method (a) was studied in detail during the investigation programme. The scope of the study included:

- The type of plant suitable to process pit water
- The size of the plant and method of treated water disposal
- The cost of a controlled treatment plant

The study brief aimed at providing some guidance on the following topics:

- Definition of the problem.
- Evaluation of data collected to date.
- Nomination of specific additional data collection required, if any.
- Statement of design criteria for the option proposed.
- Evaluation of the need for pilot plant work.
- Preliminary design of the pilot plant.
- Capital and operating cost estimation of the pilot plant.
- Order of magnitude cost for a full scale treatment plant.
- Cost of design services for a full scale treatment plant.
- Technical description of the treatment plant.
- Details of the services required for operation of the plant and how these will be provided.
- Consumption of reagents.
- A list of assumptions used and the probability of success.
- A detailed programme of works showing the time schedule for implementation of the proposed plant.

- Management of overall water handling strategy associated with water treatment.

A detailed report is included as Volume 3 of this report.

Only a summary of the water treatment plant report is presented in this section, with some typical drawings for reference.

Water Treatment Plant Summary

Introduction -

The treatment of waste solutions of water containing small amounts of heavy metals has traditionally been handled by either ion exchange or hydroxide precipitation. Ion exchange, either on resins or using solvent extraction techniques is often used where economics are such that the project is commercially viable, and hydroxide precipitation is used where the prime objective is achieving heavy metal removal at minimum capital and operating cost.

In the case of the treatment of the Rum Jungle waste water contained in Whites, Intermediate and Dysons Open Cuts, there is no demonstrably economic argument for a commercial metal recovery unit. Therefore, the process selected to be used in the treatment of these waters, is hydroxide precipitation.

Chemical Reactions -

The chemical reactions involved in this process are generally written.

$$mM^{+d} \quad + \quad dD^{-m} > MmDd\downarrow$$

where M is the metallic cation of charge +d and D is the anion of charge (-m).

In general terms, the anion could be any of a number of ions (e.g. the sulphide ion) but for the hydroxide precipitation D = OH^- and m = 1.

The reaction becomes

$$M^{+d} \quad + \quad dOH^- \rightarrow M(OH)_d\downarrow$$

The hydroxyl ion can be provided from a number of sources. However, the most common and cost effective source is from bunt on slaked lime,

$$CaO \quad + \quad H_2O \rightarrow Ca(OH)_2$$

(Burnt lime + Water) (slaked lime)

The sequence in which heavy metals drop out of solution is dependent of hydroxyl ion concentration and the solubility product of the heavy metal hydroxide.

Test Programme Results -

The laboratory test work completed in April 1982 indicates that acceptable heavy metal removal will be achieved by increasing the pH of the water to 9.6. An acceptable dissolution of heavy metal ions will take place to values expressed below:

Fe	0.5 p.p.m. or mg/litre	
Cu	0.1 p.p.m. or mg/litre	
Mn	1.0 p.p.m. or mg/litre	

Confirmatory analytical data is presently being prepared on all other metals. However, as Mn is the last metal to precipitate, the others will be reduced to below the levels outlined in the Rum Jungle Water Quality Design Targets.

It should be noted that both the calcium and sulphate levels will be higher than desirable, the upper levels being limited by the solubility of gypsum. These levels are expected to be approximately

900 to 1000 mg/l	calcium Ca
1900 to 2000 mg/l	sulphate SO_4

It will therefore be necessary for plant effluent to be diluted before disposal if recommended calcium and sulphate levels are not to be exceeded.

Precipitated Material -

The precipitated material will have a varying composition, but will contain a range of heavy metal hydroxides and sulphates, these being predominantly iron, copper and manganese. This material is only likely to re-solubilise under extremely acid conditions, and therefore, is suitable for returning as land fill.

Process Deisgn Criteria -

The process is designed for the continuous treatment of 10,000m^3 per day of polluted water from the Whites, Intermediate, and Dysons Open Cuts. Composition of feed water is expected to vary depending upon depth and the particular open cut, but is in the range of composition below for Intermediate and Whites. Dysons pit is somewhat less contaminated. (See Table I).

The plant is divided into the following sections:

1/ Reagent Handling Section
2/ Neutralization Section
3/ Solids Liquid Separation Section

General Plant Description

Lime Handling -

Hydrated lime (CaO) is received in suitable containers and stirred. It is drawn off at an appropriate rate and slaked with water, the reactions being

$$CaO + H_2O \quad Ca(OH)_2$$

The slurry is diluted and pumped at a controlled rate to No. 1 Neutralization C.S.T.R.

Flocculant Mixing -

Suitable ploymer synthetic flocculant is received and mixed in dilute solutions (1% solids) for pumping to the flocculant head tank. From this tank it is metered to the thickener clarifier and controlled on the basis of underflow density.

TABLE 1

TYPICAL FEED WATER COMPOSITIONS

OF RUM JUNGLE OPEN CUTS

Note: Allowances must be made for variations at different depths.

	Intermediate		Whites	
pH	3.5		2.5	
Fe	2	mg/litre	430	mg/litre
Cu	60	"	55	"
Ni	14	"	14	"
Co	15	"	15	"
Zn	7	"	6	"
Mn	60	"	230	"
Al	60	"	280	"
Hg	0.05	"	0.01	"
As	0.001	"	0.4	"
Ca	200	"	400	"
Mg	400	"	900	"
Na	40	"	200	"
SO_4	3100	"	8200	"

Neutralization Agitators -

Neutralization of the incoming water is effected in two continuous stirred tank reactors (C.S.T.R.s) in series, with a nominal residence time of 2 to 2.5 minutes each. These tanks have the characteristics approaching those of perfect mixers, and are discharged by overflow.

Lime slurry at 5% solids is metered into the first reaction vessel from the lime handling plant in the services area, and the pulp resulting, overflows into the second C.S.T.R. at a pH of 9.0 to 9.6.

In this pH range heavy metals are precipitated according to the general equation.

$$M^{+d} \; + \; d\,OH^{-} \quad M(OH)_{d}$$

Other reactions may also occur, precipitating minor amounts of heavy metals as insoluble sulphates or complexes with hydrated iron oxides.

The suggested residence times allow for approximately 90% of the heavy metal hydroxides to occur in the C.S.T.R.s. Reactions reach completion in the solids liquids separation section.

Re-circulated pulp from the thickener overflow is re-circulated at around 25% of thickener underflow in order to assist in providing nucleation sites for flocc build up and so assist in increasing pulp densities of thickener underflow.

Solids Liquid Separation -

In this section the solids precipitants and residual lime products are separated from the liquids. Additionally, ample residence time is provided in the plant thickener/clarifier to enable the neutralization reactions to reach completion.

Thickener Clarifier -

Pulp from the neutralization reaction flows to the feed well of the thickener/clarifier. A synthetic flocculant is metered into the thickener feed pipe at the overflow from No.2 C.S.T.R. The settling rate of non-flocculated pulp has been determined by test work, and adjusted on the basis of experience to a flocculated rate.

Indications from test work are that a minimum underflow density of 1.3% solids will be obtained. However, this rate may be increased to approximately 5% solids by the effects of pulp re-circulation and optimising flocculant addition.

The thickener is therefore, to handle an overflow of 7.0m^3/min, with a varying underflow density 1.3 to 6% solids. Re-circulation rate is variable to suit particular operating conditions.

Sludge Filtration -

The thickener underflow is pumped to plate and frame filtration presses where it is filtered on a semi-continuous basis.

Due to the semi-gelationous nature of the sludge it is unlikely to cause bogging of the thickener, and the options exist for operating by holding sludge in the thickener during discharge cycle, or operating two filters in parallel.

The nature of the cake produced is as follows:

Cake thickeness	20mm
Cake density	1500 kgs/m^3
Percent Moisture	50% H_2O

The material produced may be further dried by air blown down the filter if required, and is suitable for incorporation in land fill.

Filtrate from the press is returned to the clarifier.

Test work to hand indicates that the clarity of the thickener overflow is excellent.

Whilst the water quality is acceptable so far as heavy metals are concerned, the total dissolved solids are higher than desirable for potable water.

It will therefore, be necessary to dilute this water.

Two options are recommended for further test:

(1) Bore injection into underground aquifers.

(2) Dilution using uncontaminated groundwater.

Both options are discussed in more detail later in this section.

Water quality at this stage is as listed below:

pH	8.0 to 8.5	
Calcium Ca	800 - 1000	mg/litre
Copper Cu	0.5	"
Iron Fe	0.5	"
Manganese Mn	1.0	"
Sulphate SO_4	1900 - 2000	"
Zinc	1	"
Arsenic	0.05	"
Mercury	0.01	"
Nickel	0.01	"

Other heavy metals will be below the Australian Public Health Recommended Standard for Drinking Water.

Disposal of Treated Water -

It is proposed to dispose of the treated plant water by pumping it via a borefield into the underground aquifer system.

The area chosen for location of the bores is in a region of transmissive dolomites approximately 500m south west of Whites open cut.

It is proposed to have four production bores in on-line service, each having a capacity of 30 litre/sec. One standby bore will be provided to enable rotation of production bores for periodic backflushing.

Alternative Disposal -

An alternative to the above is to dilute the treated water with potentially clean bore water from an aquifer approximately 2km north of Whites Open Cut.

Dilution would occur by mixing the two prior to disposal into the East Finniss River system.

During the wet season all water will be diluted with surface run off and be released into the East Finniss River.

The use of groundwater during the dry season eliminates the need for expensive holding ponds, if treatment of the pit was to continue all year round.

During 8 months of each year the level of calcium and sulphates is considered to be too high for direct release into the East Finniss River.

The injection of the water into the underground system has benefits for the following reasons.

There is evidence of groundwater moving through Whites open cut and of caveneous dolomites adjacent and under the pits. Mining records have recorded water flows at various times and sink holes have been reported. The geology of the area indicates Coomalie Dolomite in the area.

If groundwater has been moving through the pit it is possible that the local plume may already be contaminated. Without any groundwater records available this is only an assumption.

The injection of treated water into this plume would only add calcium at approximately 1000 mg/litre as the only possible contaminant. The sulphates in the groundwater plume around the pit would be in the same order as the treated water as the treatment process may only slightly lower the level of sulphates during removal of metal ions.

The location for water injection has been selected at a potential junction of two aquifers, in an attempt to achieve wide dispersion of the treated water.

The only chemicals that should be of any concern are calcium and sulphate, both of which should not cause any long term pollution of aquifers during the 18 months of operation.

During the wet season the volume of surface water passing down the East Finniss and Finniss River has sufficient volume to permit a 10:1 dilution factor.

Only 5:1 dilution is required to achieve final rehabilitation standards and only 3:1 dilution to reach the interim release targets recommended in this report (Section 2.0).

The option to raise groundwater during the dry season will be investigated if the water injection method is not feasible.

For surface dilution, low calcium and sulphate concentrations would be necessary.

The groundwater around Whites would probably not meet this criteria hence the only potential source is an aquifer some 2km north of the main site.

During previous rehabilitation works, potable water was found in this region and used for drinking water. The potential flow rates are not known and for the reasons of distance, the need for low sulphate and calcium levels in the water and unknown flow rates, the injection of water close to Whites open cut is the favoured option at this stage.

In Situ Water Treatment -

During the laboratory testwork and detailed investigations of the controlled water treatment plant the main concern was the potential risk of the treatment plant failing to achieve the desired results within the time frame of the works.

A part of the overall rehabilitation strategy is the use of Whites and Dysons open cut as a dump for various overburden heaps, and the need to improve its water quality.

The reliability of the water treatment plant becomes a big factor in the overall success of the project.

A number of factors found during the continuous water treatment study have provided substantial evidence not to proceed with an insitu plant as proposed in other reports, the main reasons being -

During investigations no evidence of successful large scale water treatment using in situ lime dispersion was found. Where destratification was used, it had been generally used for removal of algae blooms or domestic water quality improvements, not for heavy metal dissolution.

The air infusion plant proposed in previous reports would require compressed air blowers in the order of 4 to 8 megawatts to achieve proper agitation and mixing.

The rubber curtain concept also proposed would be difficult to maintain in a stable vertical position due to unequal pressures being applied on each side of the curtain under certain conditions.

The contact of water to lime is one of the prime reasons for apprehension of the system. The effective use of the lime demands ideal contact and the general pit mixing method would not seem anywhere near the requirements found necessary in the laboratory work carried out.

Tests were carried out on the heavy metal sludge removed from the water samples.

It was found that very slight liquor turbity and temperature change were sufficient to break up the sludge and redistribute it through the liquor.

It is intended to backfill Whites during the same period of water treatment and any water disturbance would create a far worse effect so it may be concluded that the discharge water would still contain the heavy metals as suspended hydroxide compounds.

The cost of lime is significant and it is imperative to achieve maximum chemical efficiency from the additive. The controlled treatment plant permits better use of lime and recirculation of the thickener underflow until the reaction has been completed.

For the reasons above the in situ plant is not recommended and any detailed study of an in situ plant would not be productive.

Controlled Treatment Plant Equipment List -

An equipment list for the controlled treatment plant lists the major items involved in the plant and the costs.

It forms the basis for the cost estimates submitted in Section 4.0 of this report.

A process flow sheet and general arrangement drawing is included to describe the design parameters of the recommended treatment plant.

EQUIPMENT LIST FOR WATER TREATMENT PLANT

ITEM	QTY	DESCRIPTION	kW	TOTAL COST
PUMPS				
01	1	Plant feedwater pump Allis Chalmers PWO 8 x 6 x 17 special purpose pump with stainless steel wetted parts and shaft. Duty 116 l/s @ 10m.	30	17,000
06	1	Clarifier feed pump Kelly & Lewis 8MFV pump of cast iron construction. Duty 140 @ 10m.	15	4,000
20	1	Sump No. 2 pump Kelly & Lewis 3 - 4 vertical sump pump. Duty 30 l/s @ 15m.	7.5	4,000
42	1	Flocculent dosing pump. Prominent model B04017 stainless steel dosing pump. Duty 12.5 l/h.	0.25	1,500
36	1	Lime slurry pump (primary) Warman 3/2 BSC slurry pump. Duty	2.2	3,000
39	1	Mono pump metering pump Duty 9.1 l/s @ 4m.	2.2	3,500
09	1	Pretreator/clarifier underflow pump Mono CLR 211 425 RPM. Duty 38 l/s @ 85m.	55	18,000
14	1	Filtrate pump Kelly & Lewis 5 - 9 model 70. Duty 30 l/s @ 5m.	4	1,500
18	1	Treated water discharge pump Indeng VRE 6/8 pump. Duty 120 l/s @ 100m.	150	26,000
19	1	Sump No.1 pump Kelly & Lewis 3 - 4 vertical sump pump Duty 30 l/s @ 15m.	7.5	4,000

ITEM	QTY	DESCRIPTION	kW	TOTAL COST
MAJOR ITEMS OF EQUIPMENT				
25 28 29	1	Baghouse for lime dust control. Comprising 2 x DLM - 4 - 4 - 15 pyramid hoppers each with motorized rotary valves	1	31,500
		duct work associated with baghouse.		6,000
24	1	Lime transfer blower (dump hopper to storage silo) Capcity 30 TPH.	7.5	25,000
33	1	Wallace & Tiernan lime staking system Capacity 40 TPD.	3	65,000
08	1	Dorr Oliver pretreater/clarifier 30m Ø supply comprises mechanism and recirculation pump.	0.37	120,000
10 11	2	Shriver plate and frame filter presses semi-automatic operation size M48-75. Capacity approx 40 TPD dry solids.	1.5	300,000
44	1	Lime transfer screw 150 Ø	1.5	6,000
MISCELLANEOUS ITEMS OF EQUIPMENT				
23	1	Bin activator 2.4m Ø - for lime dump hopper.	2.2	12,000
26	1	Baghouse blower. Chicargo Size 30 SISW industrial fan complete with motor and drive. Duty 28800 m^3/hr @ 200mm	22	4,000
27	1	Baghouse transfer screw conveyor 150 Ø x 6m long.	2.2	10,000
30	1	Dalamatic DLMV9/15W insertable filter - for lime storage silo required air supply 3.9m^3/hr @ 45 kPa.		2,000
32	1	Bin activator 2.4m Ø - for lime storage silo.	2.2	12,000
35	1	Grit removal conveyor 450mm inside x 15m long.	2.2	12,000
38	1	VLBT-10 chemineer mixer - for 5% lime slurry holding tank.	0.75	3,000
03 05	2	2HTD-55 chemineer mixers 0 for neutralizing tanks.	8	11,500
41	1	VLBT-10 chemineer mixer - for dozing tank	0.75	3,000

ITEM	QTY	DESCRIPTION	kW	TOTAL COST
15	1	Filter cake stacking conveyor 900mm inside x 30m long. Capacity 6 tonne/cake drop @ 2 drops every 4 hrs.	5.5	25,000
21	1	Atlas Copco automan A12 compressor 30 a/s @ 690 kPa.	15	5,500
		TOTAL		$736,000

STEELWORK - HOPPER, TANKS, BINS AND CHUTES

22	1	Lime dump hopper. 4m Ø x 4.5m high conical bottom ex 6mm plate. Capacity: approx 30 tonnes.
31	1	Lime storage silo 4m Ø x 10m high conical bottom ex 6mm plate. Capacity: approx 100 tonnes.
34	1	Lime slurry pump hopper, 1.2m Ø x 1.5m high conical bottom ex 6mm plate. Capacity: approx $0.75m^3$.
37	1	5% lime slurry tank 2m Ø 2m high falt bottom ex 6mm plate. Capacity: approx $6.25m^3$.
02 04	2	Neutralizing tanks 2.5m Ø 3.5m high flat bottom ex 6mm plate. Capacity: approx $14.7m^3$.
07	1	Pretreator/clarifier tank. 30m Ø 4m high flat bottom ex 6mm plate complete with launder.
16	1	Pressure filter filtrate hopper 1.8m Ø 2m high conical bottom ex 6mm plate. Capacity: approx $2m^3$.
12 13	2	Pressure filter cake discharge hopper. Opening size 1.53m inside x 6.0m long, outlet size 0.9m inside x 6.0m long ex 6mm plate.
17	1	Clear water tank. 4m Ø 3m high flat bottom ex 6mm plate. Capacity: approx. $38m^3$.
40	1	Flocculent tank 1m Ø x 1.3m high flat bottom ex 6mm plate. Capacity: approx $1m^3$.

Other Investigation Studies -

Some minor studies were carried out to assist in the overall strategy of rehabilitation. Due to fund restrictions they were kept to a small scale and may require further test work once the need for the studies has been accepted.

3.2.4 Metallurgical Analysis of Dysons Overburden Heap -

The use of Dysons overburden heap as a covering material for otherheaps was considered practical because vegetation had re-established on part of the heap.

Visual inspection indicated massive surface pyrites and electron microscope analysis of some grab samples proved that there was 50% pyrite in the samples. After close examination of the grassed areas on the heaps it was noticed that the material on the surface was fine grained and different to the underlying broken rock.

It has been concluded from the levels of pollution from Dysons overburden dumps and from examination of past samples that the pyrite in Dysons overburden is considerably less reactive than the pyrites in the black shales in Whites and Intermediate overburden.

The use of Dysons close to any vegetation layers has not been recommended in this report.

3.2.5 Hydrological Results -

During November 1981 three new gauging stations were constructed and another upgraded in the Rum Jungle area as part of the current investigation programme.

There were insufficient funds to supply the stream gauging and sampling instruments for the stations. The value of the 1981 wet season hydrological results were considered of great importance for design parameters of a proposed water treatment plant.

Strong recommendations were put forward in the Implementation Report - October 1981, for the collection of stream gauging and water quality results during 1981/1982 wet as previous results of water flow were much higher than calculations indicated.

To assist the project team, the N.T. Water Division installed continuous gauging equipment from their own resources and have collected the necessary data from reliable gauging stations.

The stations still require rating before final values of total water passing through the Rum Jungle catchment can be made available.

The results will be used to validate the data put forward in 'The Summary' and the 1982 - 1983 results from the same stations will assist in determining release rates from the treatment plant during first wet season after it is in operation.

It is recommended in this report to complete the gauging and sampling stations to provide data for the water treatment plant release programme and long term monitoring of the site.

3.3. Recommended Solutions and Measures

After consideration of the 'strategy D' measures, the alternative proposed by the Department of Housing and Construction - Canberra Region and the results of curren investigations, we herewith recommend the following measures be adopted as a solution to the Rum Jungle pollution problems. They should achieve the rehabilitation objectives described in Section 2 of this report.

3.3.1 Copper Head Leach Pile -

'Strategy D' recommended the heap leach be dumped into Whites Open Cut and covered with low pyritic rock fill from Dysons overburden.

This report recommends that the copper heap leach be placed in Dysons Open Cut instead of Whites for the following reasons:

The water treatment study indicates that most of the copper has precipitated out of solution in the pH range of 6 to 8.

At these high pHs, bacterial action is retarded and pyritic action is not expected to be a major source of acidic contamination in the pit.

However due to the possibility of acid waters entering Whites Open Cut from residual action in overburden heaps it is considered prudent to place the copper heap leach into Dysons Open Cut, where no such possibility of recontamination exists.

By placing the copper heap leach into Dysons Open Cut it will prevent any reaction as the pit will have all water removed from it, and an impervious cover will prevent the ingress of oxygen and water and it is in a better location for containment of potentially reactive wastes.

The final contours will reduce the catchment area and any failure of the impervious cover would not cause re-contamination of the East Finniss River.

Removal of the heap from its present location is essential for the same reason. Past records indicate copper liquors permeated through river gravels and old faults eventually returning to the East Finniss River system.

Its relocation prevents any such reoccurrence and improves the aesthetics of the area considerably.

The results of testwork indicates Dysons overburden to be high in pyrites, although it is clearly less reactive than Whites or Intermediate overburden. Its use as underwater cover is therefore questionable, as under certain circumstances it may accelerate metal dissolution thus reducing the effectiveness of the water treatment programme.

The probability of its success in the long term is considered more likely than the 'strategy D' proposal, and the cost of moving Dysons overburden to Whites Open Cut as a cover is greater than shifting the copper heap leach to the smaller Dysons Open Cut and covering it with Dysons overburden.

The possibility of an effective underwater cover was considered unlikely to achieve any real effect.

3.3.2 Tailings Dam -

It is recommended that the waste material in the Tailings Dam area be removed entirely to Dysons Open Cut: rather than covering the site with an impervious soil cover as proposed in 'strategy D'.

At present the tailings cover an area of 32 hectares with depths ranging from one metre to 300mm. The area has a large surrounding water shed and is relatively flat, leading to a creek, which joins into the East Finniss River. The tailings material is highly acidic and the area is the most aesthetically displeasing of all category 3 pollution sources in the Rum Jungle mine site area.

After careful examination of the problem the location of the Tailings Dam was the major concern. It is located in a natural river course which attracts wet season runoff from a large surrounding area. The proposed soil cover in the area would be susceptible to early failure if control drainage channels failed to direct the water along defined paths. They would require a substantial amount of protective rock and concrete.

The depth of the tailings is quite shallow and currently spread over a relatively large area, creating an expensive covering operation for a thin layer of tailings.

The prospect of establishing a confined site where the cover could be minimised and the volume of tailings maximised was investigated. Rather than creating a new quarry styled pit, which would increase costs, Dysons Open Cut was examined in detail, as a likely containment site.

Its topographical features suited the proposed operation as it is a small pit with a high northern perimeter allowing substantial filling with a minimum of impervious soil cover.

The records of groundwater movement through the pit during operations indicated insignificant flow rates, consistent with the geology of the area. The addition of tailings to the pit should not increase the level of contaminants already present, in any surrounding groundwater aquifer, as the pit is already partially filled with tailings from the old treatment plant.

The costs of moving the tailings and backfilling Dysons Open Cut with Dysons overburden and the copper heap leach, is significantly lower than covering the tailings area.

The main reasons for recommending the removal of the tailings is the potential success and cost of the solution.

In our opinion the long term durability of an impervious soil cover in the tailings area is suspect due to erosion each wet season. It was not considered an acceptable solution to propose any works which require long term maintenance.

At the lower end of the present tailings site, the water table is known to rise above the existing surface which may cause an early breakdown of any impervious cover.

The regrowth of vegetation may be a problem if the acidic properties of the tailings migrate upwards through the imported soil.

The overall cost of the tailings cover is significant and dramatically increases the borrow pits needed to provide the necessary soils, whereas shifting the tailings into Dysons can be economically achieved and a 8 metre rock cover over the top is proposed using some 722,000 cubic metres of Dysons overburden, then a final compacted soil cover over a relatively small area.

Removal of the tailings in previous reports has not been recommended because of the potential health hazard created by disturbing the tailings and the potential bogging of machines at the western end of the Tailings Dam.

The uranium mining industry have developed codes of practice for mining uranium ore. The application in this instance may be different to pit mining but provided air conditioned operator compartments are used on all equipment, daily equipment cleaning and inspection is carried out and all the necessary medical checks and camp hygiene regulations are enforced then it is considered practical to shift the tailings without placing equipment operators at risk.

Opinions from experienced earthworks contractors re the problem of machine bogging, firmly ruled out any difficulties provided track machines were used and the work was carried out during the dry season.

The overall benefit in shifting the tailings as one of the first activities allows the remaining works to proceed as a large civil engineering project without any concern by the public, of a large uncontrolled radioactive waste being left in the centre of the project activities, which may create adverse industrial and press reports.

The use of Dysons overburden heap and the copper heap leach, to cover the tailings is discussed in this section. The heap has been found to have massive pyrites and would be better used in the pit which is a short haul from the overburden area. The relatively deep cover planned for the tailings eliminates any possible breakdown of the cover during the expected 100 year life of the works.

After removal of tailings materials and approximately 200mm of affected soil directly below it, it is recommended to treat the natural surface with agricultural lime, then import 200mm of top soil.

Once suitable mixing has been achieved it will be necessary to shape the area, provide rip-rap lined drainage channels and erosion protection berms before re-seeding the Tailings Dam area.

In this area it is recommended to plant trees similar to the surrounding vegetation.

All migrated tailings further down the creek would be removed during the same phase of operations and the creek beds stripped of affected soils, treated and mixed with new topsoil, then allowed to revegetate naturally.

3.3.3 Dysons Open Cut -

It is recommended to:

Remove the water in the pit to Whites Open Cut for treatment before it's release to the East Finniss River and underground aquifers.

A 150mm pipeline is proposed to transfer the water by pumping once the treatment plant is in operation.

Fill the eastern 'pan handle' end of the pit with $240,000m^3$ of tailings from the Tailings Dam.

Place $174,000m^3$ of the copper heap leach and $722,000m^3$ of Dysons overburden over the tailings, totally displacing all pit water and providing an 8 metre cover over all tailings deposits.

The final profile of rock fill will suit the natural contours of the original topography and provide a dome shaped final surface for the impervious covers with 1 vertical to 8 horizontal slopes.

The top 450mm of the transported overburden would be compacted to form a filter bed sufficient to allow a transition layer from the course open rock to the more finely grained imported gravelly clay.

A 300mm compacted clayey-gravel would be placed above the filter bed to act as an impervious water barrier.

A final 300mm layer would primarily support vegetation with the upper portion of the layer being constructed from a fine rip-rap material blended with clay type soils. It will be loosely compacted using track and wheel loaders during the spreading operation.

The final profile of the pit will be gentle dome shape sloping down from the natural bank of the northern side to the southern side. The dome shape would minimise the length of runoff in any one direction (see typical profiles included in this report) hence minimising the risk of erosion.

Once all mass earthworks have been completed, erosion berms would be established to prevent sheet and gully erosion before final seeding of native grasses commenced.

The vegetation programmes have been scheduled for October to December each year to minimise the need for reticulation.

Haul roads into the eastern and western end of Dysons Open Cut would be established during the first phase of the operations. There are existing access roads into the area previously used for hauling tailings waste to the pit.

Transportation of the tailings has been scheduled for the 1983 dry season, thus preventing any machine difficulties in the Tailing Dam.

The displaced water will move to the wider 'pan' end of the pit during tailings filling operation.

The displaced water will not be removed from the pit until the water treatment plant commences operation in December 1983. This will restrict backfilling of the pit scheduled to be carried out in two stages: tailings in 1983 and remaining copper heap leach/Dysons overburden in 1984.

It is intended to dump the tailings underwater at all times to eliminate any radon or radiation problems from the disturbed tailings. The 'pan handle' end of the pit should take the 240,000m^3 and still leave approximately 500mm of water cover.

3.3.4 Intermediate Open Cut -

It is recommended that the Intermediate Open Cut be connected to Whites Open Cut and a water treatment plant constructed adjacent to this pit.

Intermediate pit water would be treated at the rate of 10,000m^3/day and released to the East Finniss River during the wet season and pumped into underground aquifers during the dry season, depending on the results of tests recommended in this report.

The rate of water treatment has been selected to allow backfilling of Whites and Dysons Open Cut and inflow of groundwater into the connected pits.

Once all Whites pit displaced water has been treated and released, the treatment plant will continue to treat all remaining pit water by drawing out of the Intermediate pit and returning the higher pH water to Whites Open Cut which will displace untreated water via the connecting channel back to the Intermediate pit for treatment.

It is expected that all water can be treated in 18 months creating a stable condition in the pit where metal dissolution would have ceased and the sources of acidic water substantially reduced by reshaping and covering Whites overburden heap and backfilling the southern side of Whites Open Cut.

The water treatment plant has been described in detail in Volume 3 of this report. It's function is to raise the pH of the existing water and allow dissolution of heavy metals such as copper, zinc and manganese which will be removed with other contaminating sludges in filter presses. The treated water has high calcium and sulphate t.d.s. levels and a pH of 8 to 9 on return to the pit or river water course.

The dilution effects gained by the wet season rainfall or underground aquifers would be sufficient to reduce the total concentrations to the expected interim rehabilitation standards (see Section 2 of this report).

The surrounds to the Intermediate Open Cut would be cleaned up, graded and tyned to permit natural revegetation.

Backfilling of the Intermediate pit is not recommended nor diversion of the East Finniss River directly into this pit.

For long term flushing of both pits and a lower river diversion cost, this report recommends that the river be eventually diverted into Whites Open Cut at the end of the rehabilitation works and the interconnection between the pits remain a permanent feature.

3.3.5 Whites Open Cut -

It is recommended to:

Dump Whites North Overburden Heap into Whites Open Cut on the southern side of the pit - volume 151,000m^3.

Removal of Whites North Overburden Heap will assist in reshaping the area between the diversion channel and the junction of the Acid/Sweetwater Dams. It is recommended to divert the East Finniss River, (which flows through the Sweetwater Dam) into Whites Open Cut. By removing the Whites North pile it allows access to Whites pit by the shortest route possible.

A secondary benefit of removing the heap into Whites pit is it's effect on restricting water movement through the pit by dumping the waste material around the southern side where there is evidence of acidic water contamination.

The pH level of the pit water is considered the most important aspect in achieving equlibrium to prevent heavy metals dissolution into the pit over a long period after rehabilitation has been completed.

Previous reports have expressed doubts as to the long term success in maintaining a pH level of around 7 because of bacterialogical action of pyrite in the pit walls. However, an assessment of the area of reactive surface of the pit walls indicates that this is not likely to contribute significantly to long term problems, as the rates of reaction are related to surface area. The walls of the pits have a very low surface area compared with that of the broken overburden dump.

Experience in copper leaching at Gunpowder, North Queensland, supports this assessment.

As a result of our investigation it is doubted that the cause of the low pH in Whites open pit water is due to the acidation of pyrite in the pit walls. It appears more likely that the low pH is due to the ingress of acidic runoff and seepage from Whites Overburden Heaps.

Past reports indicate the acidic levels to be higher on the southern side of the pit walls. On that side there are old river gravels that intrude into the pit walls and the old pit haul road used to rise out of the pit on the same side.

The Whites Overburden Heap is a known source of acidic pollution. It lies on the southern side of the pit and there is a possibility that the acidic liquor is leaching out of the bottom of the overburden heap and through into the pit via the old river course.

The haul road may also be creating a shear plane along the loosley compacted backfill and further acidic water may also be entering Whites pit on the same southern side.

It is therefore possible that once Whites Overburden Heap has been reshaped and covered with an impervious clay and gravel structure, the amount of acidic liquors entering the pit may be significantly reduced.

Under the circumstances given above it should be possible to treat the remaining pit water and achieve a state of equilibrium once all water has passed through the proposed lime treatment plant.

In an attempt to inhibit the pyritic action in the pit it is proposed to dump the Whites North Overburden into the pit on the southern side (151,000m^3). This will act as a barrier to any surface action and when all overburden material has been placed, a layer of clayey-gravel is proposed to assist by infiltration of the broken ore and to blind the rock surfaces to further inhibit the action.

It is proposed to dump 100,000m^3 of the blinding clay, to achieve the desired result. A large amount will slump into the base of Whites which will assist in covering tailings already in the bottom of the pit.

As an additional long term measure it is recommended to dump 5,000 tonnes of crushed limestone with the blinding clay to provide a potential balance against any long term pyritic action attempting to lower the pH level of the water, once the treatment plant ceases operation.

Both the blinding clay and the limestone should be considered as conservative measures to counter a complex problem of the sources of the acidic pollution in Whites Open Cut. It may not be necessary, however the costs have been included in the project estimates for added assurance in achieving the rehabilitation objectives.

The diversion of the East Finniss River into Whites Open Cut will assist the long term stability of the pit water.

It is expected to receive some 25 x $10^6 m^3$ each wet season into the pit. The residual, combined volume of Whites and Intermediate once all work is completed will be 3.2 x $10^6 m^3$, allowing considerable flushing each year providing short circuit water flows can be overcome by introducing the incoming water some thirty metres under the surface.

There should not be any concern about detrimental contamination of the incoming water each year as there is no evidence of any radionuclides concentration levels above current drinking water standards and without any heavy metals such as the copper heap leach pile, no build up of metals should occur, particularly when the pH level remains at 7 or above.

The flushing will only remove any minor increase in the acidic level which when diluted some 10:1 would be insignificant to the long term water quality release standards.

During the treatment of the water it is proposed to remove the heavy metals in the form of a gelataneous sludge. It will have a 50% pulp density, thus allowing it to be handled by pump or truck. The process of removal is by way of plate and frame filter presses, eliminating any need for large evaporation ponds holding low pulp density residues.

The filter cake can be placed in certain areas of the borrow pits where the more pure clays will be removed from. The borrow pit will contain the cake, preventing water from coming into contact with it. Once properly covered, the metals in the cake will not redisolve even if by chance it is again subjected to water.

The final solution to Whites must be to treat the water in the above manner so that the pit can be returned to a safe recreational area where no health risks exist.

3.3.6 Water Treatment and Disposal

The disposal of treated water during displacement has been investigated and it is proposed to carry out tests on underground injection into aquifers adjacent to Whites Open Cut.

The treatment of the water will remove all heavy metals to concentrations below 1mg/litre, but will raise the calcium level to some 2000 mg/litre.

The level of sulphates would remain in the same order as the present pit water so any injected water would only increase the amount of calcium present.

The amount of water underground is not known, however recent bore field works around Batchelor would indicate that a number of bores operating at 30 litres/sec. would be capable of discharging into the underground aquifers.

The position to be recommended for trial injection is only 500 metres to the west of the Intermediate Open Cut, where two aquifers diverge, giving the greatest possibility of dilution and dispersion.

In the event that these tests fail, it may be possible to raise uncontaminated water from an aquifer 2 km to the north of the tailings dam, where a construction camp was located in 1979 and potable water was found.

If the volumes prove sufficient it may be feasible to dilute the treated water and maintain surface stream flow all year round.

The underground injection method remains the most attractive option and a test programme which would lead to the installation of five bores is recommended in Volume 3 of this report.

The technology used in the design and selection of equipment has been based on well known conventional techniques.

It was not considered necessary to construct a pilot plant for this reason, except for testing a method of water injection before proceeding with a final method of water discharge.

The results of the bore tests would not change our recommendation to use a controlled conventional continuous treatment plant even after taking account of its high capital cost for a 2 year operation. The achievement of the rehabilitation objective without risk of failure has made its selection necessary.

The whole programme revolves around total backfilling of Dysons Open Cut and partially filling of Whites Open Cut, hence the reliable operation of a water treatment plant has become a critical item in the overall success of the project.

The insitu method of treatment using relatively unknown techniques and equipment was not favoured for a number of reasons given in Section 3.2.3.

At the end of the treatment phase it is desirable to relocate the East Finniss River back through Whites Open Cut for annual flushing of the pit.

3.3.7 Whites Overburden Heap -

It is recommended to:

Reshape Whites Overburden to reduce the side slope angles to 1:3 horizontal and re contour the top of the heap to form drainage channels into a common central point. From the collection point it is proposed to construct a substantial concrete or rock gabion drain off the heap, into a retention pond before entering the East Finniss River.

During reshaping the upper 450mm of the heap will be compacted to provide a more dense layer that will form the filter bed for the imported soil cover to be placed over the top.

Once all shaping has been completed, it is proposed to cover the heap with a tightly compacted layer, 300mm thick of an impervious clayey-gravel, then a final loosely compacted soil, with a light rip-rap surface, for initial erosion protection.

The side slopes of the heaps would have a final 450mm thick layer over the impervious clay barrier to provide better protection against infiltration and erosion.

The side slopes have been designed with 5 metre wide berms every 9 metres down the slope to protect the soil covers from erosion.

The drainage channels on the top and sides of the heap would be lined with rip-rap which is available locally in the form of rippable phyllite and granite.

Concrete or rock lined drains would only be used from the main collection points where volumes of water were relatively large and final side discharge channel leading to the East Finniss River where velocities may be relatively high.

Once all soil covers were completed a revegetation programme would seed the area with native grasses, after soil treatment, using agricultural lime only when necessary.

Reticulation during the first dry season may be necessary to establish root growth before the first wet season.

3.3.8 Whites North Overburden Heaps -

It is recommended to shift all of Whites North Heap into Whites Open Cut - volume 151,000m^3.

The heap is situated at the junction of the Acid/ Sweetwater Dams and between the diversion channel and Whites Open Cut.

The topography of this area is such that considerable ponding of acidic wastes occur which may be a source of pollution into

Whites Open Cut. If the heap was reshaped and covered, the toes of the reshaped heap would be below the perimeter of Whites Open Cut causing run off problems.

It is recommended to divert the East Finniss River back into Whites Open Cut. To achieve it, the best route is from the Acid/Sweetwater Dams junction through the middle of Whites North Overburden. By shifting the heap it allows for a low cost diversion of the river and removes the catchment outside Whites pit.

The overburden may assist in reducing the source of acid pollution into Whites as previously discussed.

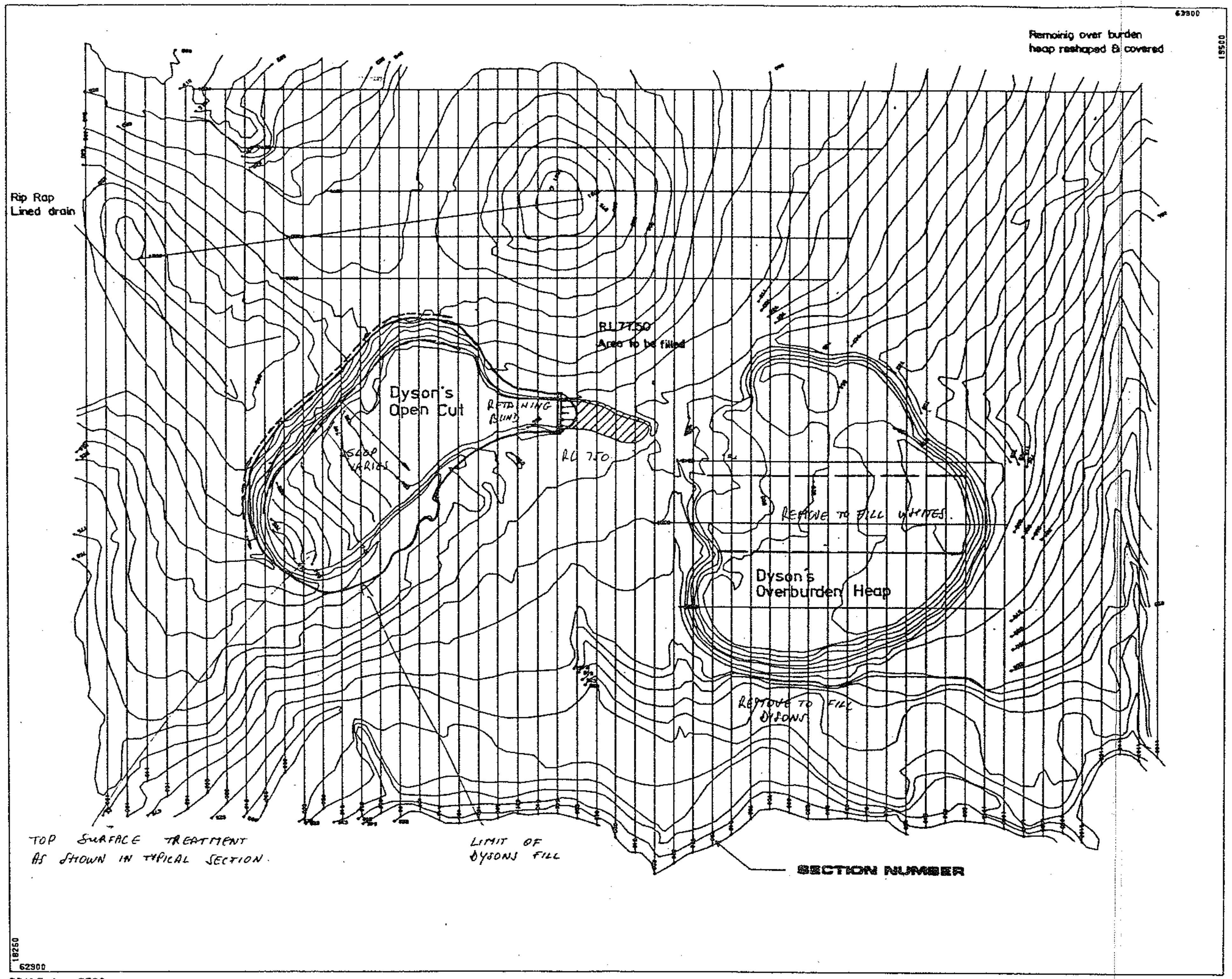
Aesthetically the area around Whites North Overburden Heap is very untidy and its removal would permit regrading and contouring of the area which would enhance the surrounds of Whites Open Cut and allow a more attractive recreational area to be established in this vicinity.

The short haul to Whites Open Cut is relatively inexpensive and provides a balance of work for equipment, during the wet season, rather than extending the need for clay and borrow pit rehabilitation.

3.3.9 Intermediate Overburden Heap -

It is recommended to carry out the same measures as proposed for Whites Overburden Heap.

- Reshape the heap and compact the top 450mm of waste rock.
- Cover the top and side slopes with 300mm of compacted gravelly clay to form an impervious water barrier.
- Cover the impervious barrier with a 300mm thick loosely compacted layer of topsoil and light rip-rap.
- Drainage channels and side slope protection berms during final contouring of overburden heaps and impervious covers.
- Treat the top soil with agricultural lime if necessary and seed the reshaped area with native grasses.



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MINING & PROCESS ENGINEERING SERVICES PTY. LTD.

No	BY	DATE	REVISION	APPROV

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PLANT NORTH U.N.O.

CLIENT: DEPT. OF TRANSPORT & WORKS (N.T.)

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KEY PLAN - DYSON'S

REV No

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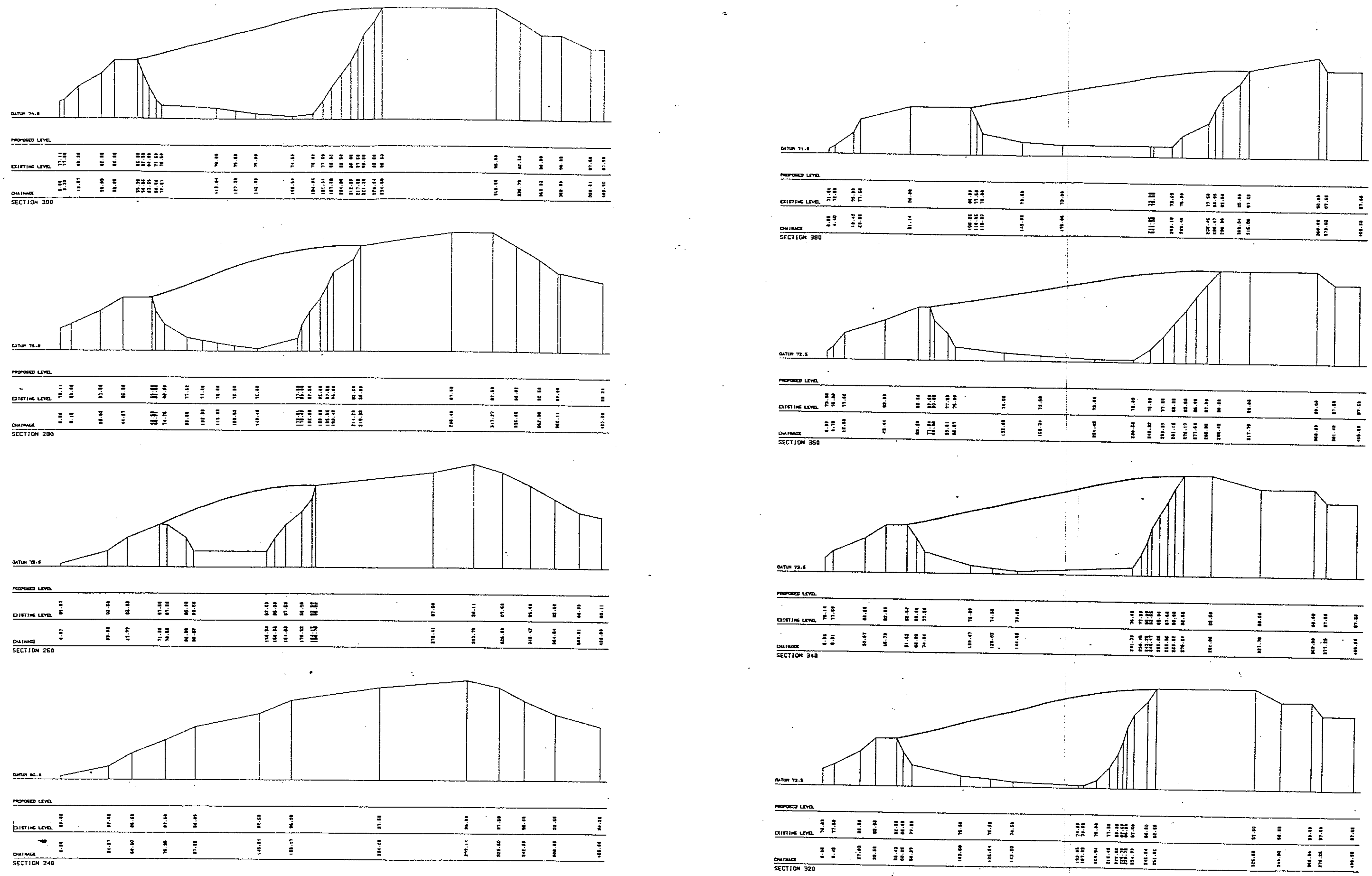

Meehan Burgess & Yeates
Consulting Engineers & Geologists

Approved for construction by
Meehan Burgess & Yeates

Date

ASSOCIATED SURVEYS (AUST.) PTY. LTD.

DRAWING No. | REFERENCE DRAWINGS

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PLANT GRID NORTH

DYSON'S

CLIENT
N.T. DEPT. OF TRANSPORT & WORKS

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DYSON'S TYPICAL SECTION

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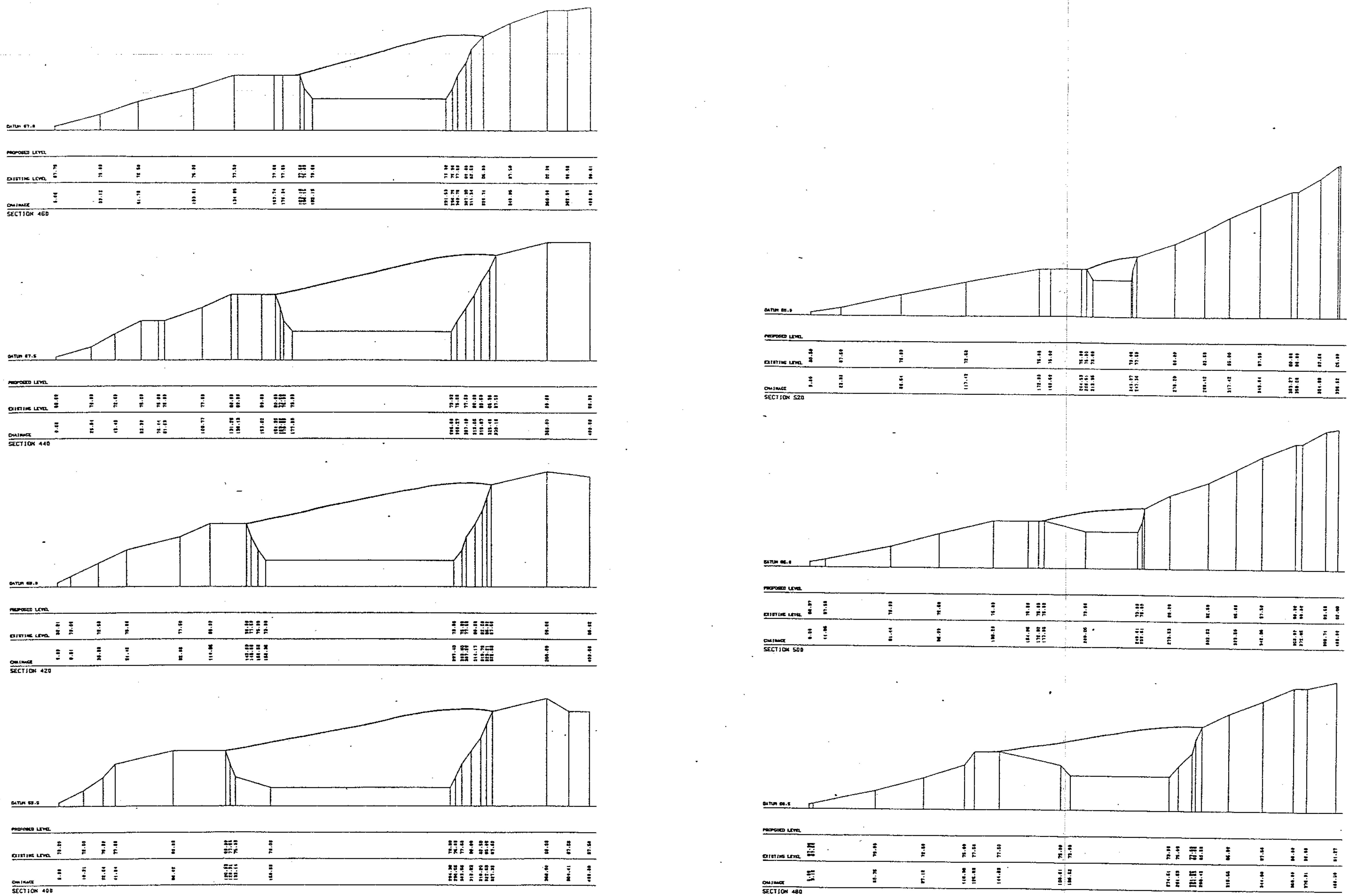

Meehan Burgess & Yeates
Consulting Engineers & Geologists

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DYSON'S

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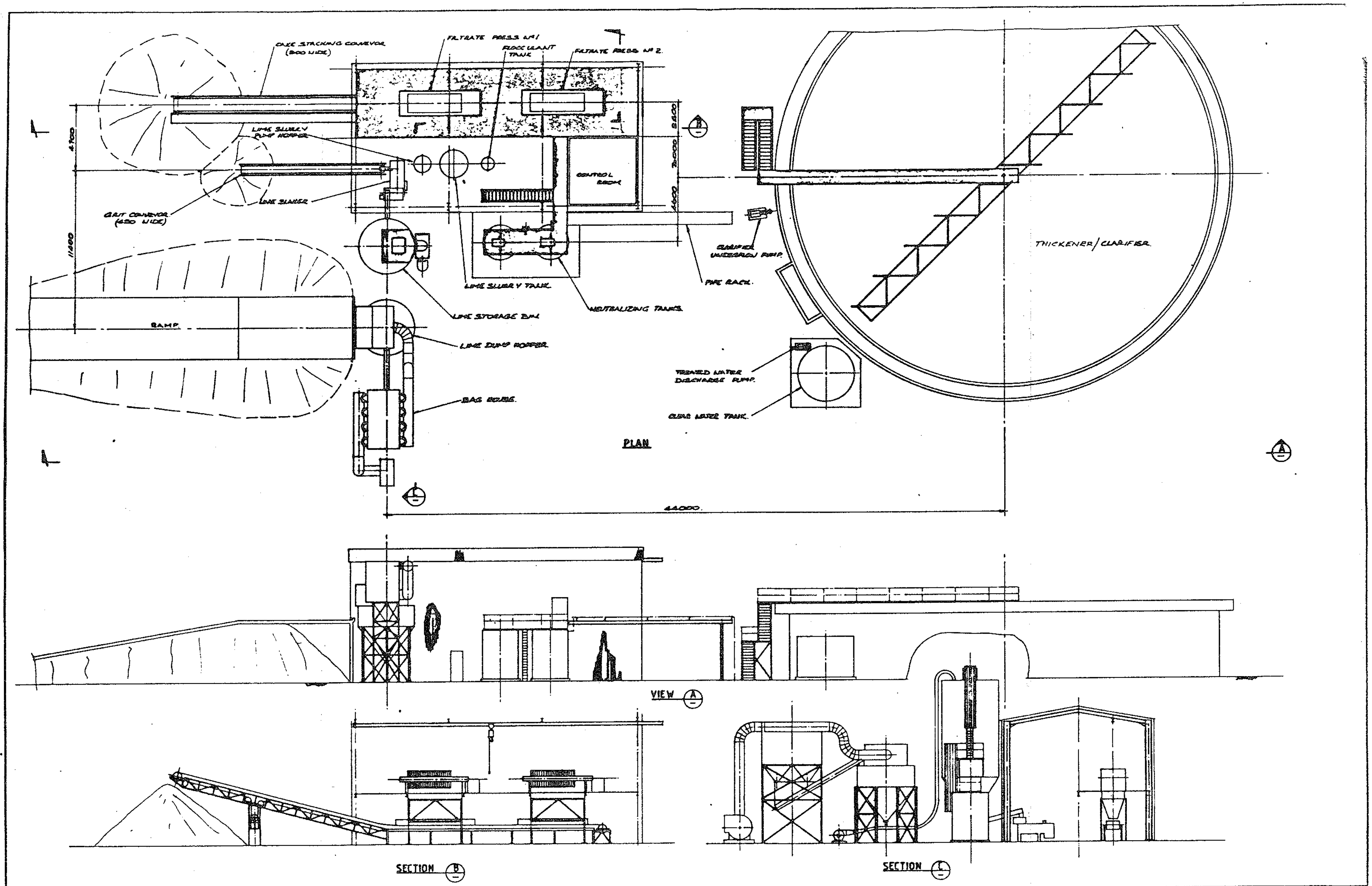

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2/3 WHITEFIELD ST, DARWIN

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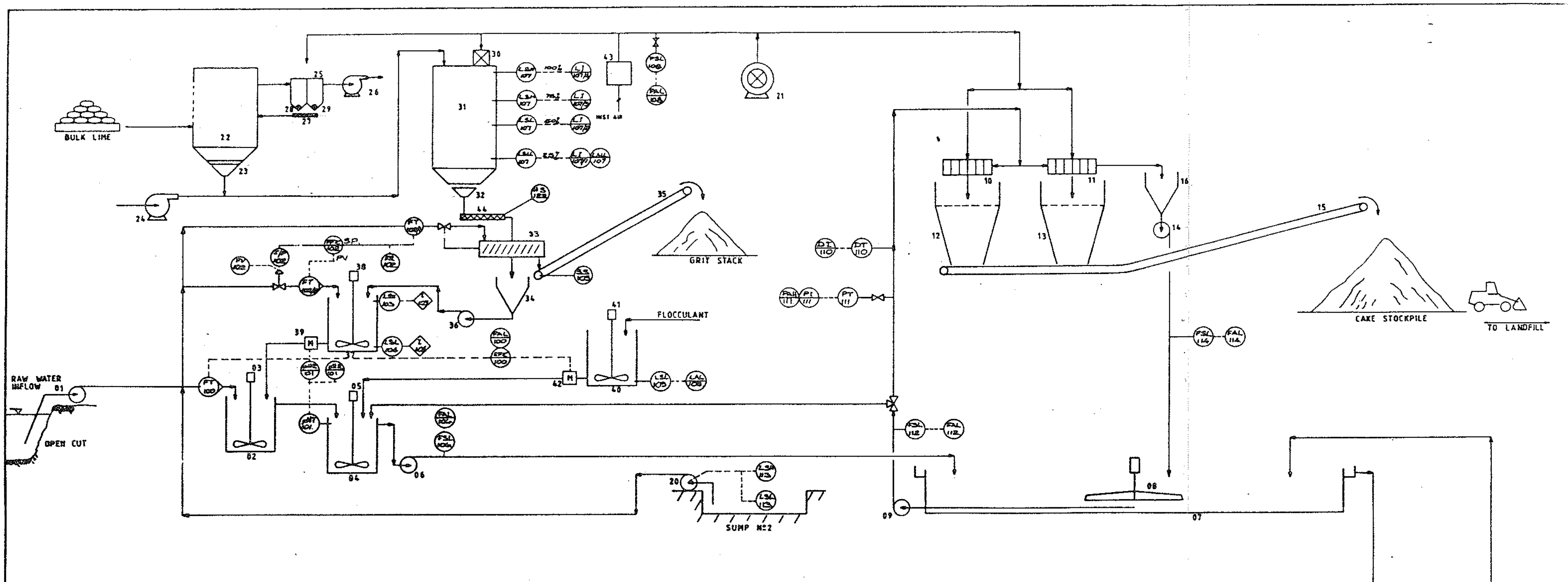
PLANT NORTH

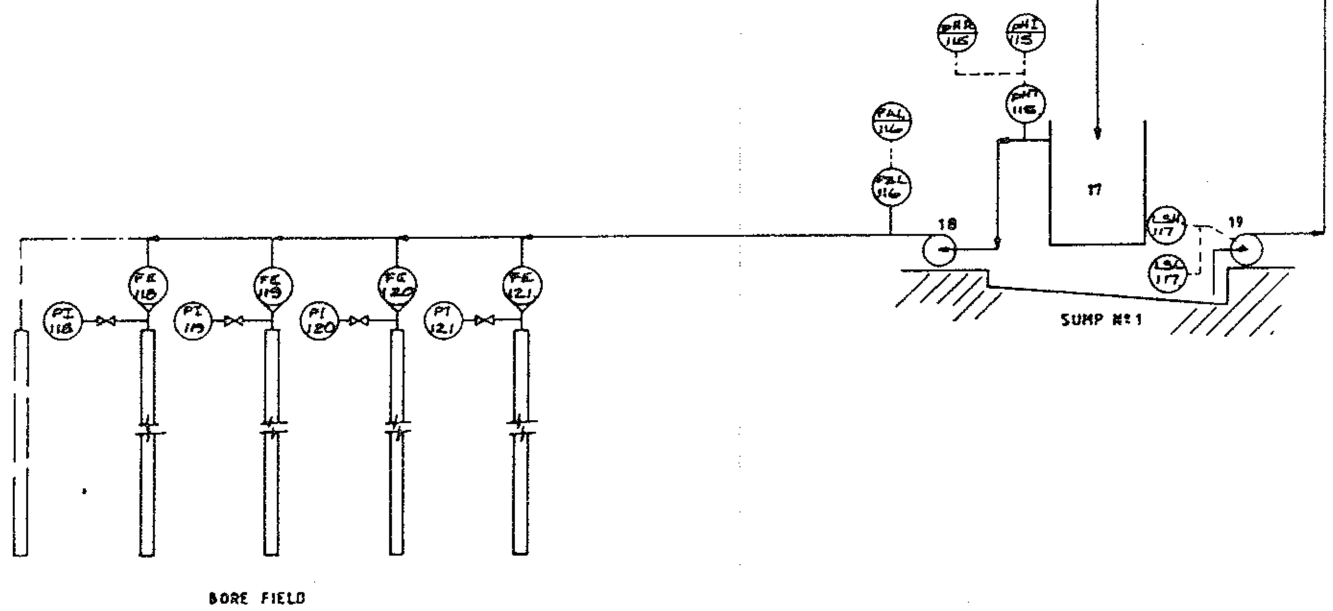
CLIENT THE NORTHERN TERRITORY OF AUSTRALIA DEPARTMENT OF TRANSPORT & WORKS

TITLE RUM JUNGLE REHABILITATION PROJECT WATER TREATMENT PLANT PLANT LAYOUT

SIZE B1 SCALE 1:100

DRAWING No RJR-00/G-001





ITEM No	DESCRIPTION	kW RATING
44	LIME STORAGE BIN SCREW FEEDER	1.5
43	INSTRUMENT AIR DRIER	
42	FLOCCULANT METERING PUMP	0.25
41	FLOCCULANT TANK AGITATOR	0.37
40	FLOCCULANT TANK	
39	LIME METERING PUMP	2.2
38	LIME SLURRY TANK AGITATOR	0.75
37	LIME SLURRY TANK	
36	LIME SLURRY PUMP	2.2
35	GRIT CONVEYOR	2.2
34	LIME SLURRY PUMP HOPPER	
33	LIME SLAKER	3
32	LIME STORAGE BIN - BIN ACTIVATOR	2.2
31	LIME STORAGE BIN	
30	LIME STORAGE BIN - INSERTABLE DUST COLLECTOR	
29	BAG HOUSE ROTARY VALVE No 2	1.1
28	BAG HOUSE ROTARY VALVE No 1	1.1
27	BAG HOUSE SCREW CONVEYOR	2.2
26	BAG HOUSE BLOWER	22
25	BAG HOUSE	
24	LIME TRANSFER BLOWER	22
23	LIME DUMP HOPPER BIN ACTIVATOR	2.2
22	LIME DUMP HOPPER	
21	PLANT AIR COMPRESSOR	15
20	SUMP No 2 PUMP	7.5
19	SUMP No 1 PUMP	7.5
18	TREATED WATER DISCHARGE PUMP	180
17	CLEAR WATER TANK	
16	FILTRATE HOPPER	
15	CAKE STACKING CONVEYOR	5.5
14	FILTRATE PUMP	4
13	FILTRATE PRESS No 2 - CAKE DISCHARGE HOPPER	
12	FILTRATE PRESS No 1 - CAKE DISCHARGE HOPPER	
11	FILTRATE PRESS No 2	0.75
10	FILTRATE PRESS No 1	0.75
09	CLARIFIER UNDERFLOW PUMP	55
08	CLARIFIER RAKE	0.37
07	THICKENER / CLARIFIER	
06	CLARIFIER FEED PUMP	15
05	NEUTRALIZING TANK No 2 AGITATOR	4
04	NEUTRALIZING TANK No 2	
03	NEUTRALIZING TANK No 1 AGITATOR	4
02	NEUTRALIZING TANK No 1	
01	PLANT FEEDWATER PUMP	30

EQUIPMENT LIST

No.	BY	DATE	REFERENCE DRAWINGS

MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

2/3 WHITEFIELD ST DARWIN

No.	BY	DATE	REVISION	APPROV

CLIENT APPR.		
PROJECT APPR.		
DESIGN APPR.	18/5/82	
CHECKED	18.5.82	
DRAWN	14.5.82	

PLANT NORTH

CLIENT THE NORTHERN TERRITORY OF AUSTRALIA DEPARTMENT OF TRANSPORT & WORKS

SIZE B1 SCALE N.T.S.

TITLE RUM JUNGLE REHABILITATION PROJECT
WATER TREATMENT PLANT
PIPING & INSTUMENTATION DIAGRAM

REV No

DRAWING No RJR-00/P-001

SECTION 5.3

PROJECT SCHEDULES

3.3.10 Acid and Sweetwater Dams -

It is recommended to generally follow 'strategy D' proposals:

During the dry season excavate the river courses and remove debris and other materials blocking the water courses, to prevent flooding during the wet season, over a large uncontrolled area, which inhibits natural regrowth.

Once the creeks have been retrained it is recommended to raise the banks approximately 500mm with non pyritic rock fill from one of the overburden heaps, so the early wet season rains do not return to the present flood plains.

This would allow time to remove any acidic top soil from the stream banks, treat the banks with agricultural lime and tyne in a loose layer of top soil and rip-rap.

Natural regrowth in this area is quite evident in areas that are not subject to long term submergence during the wet season.

It is proposed to construct sufficient erosion protection berms along the two river courses to allow the flood plains sufficient time to regenerate naturally.

The old dam walls at the junction of the two dams would be removed and a new river course constructed from the junction into Whites Open Cut, once all rehabilitation works were completed.

3.3.11 Other Areas -

A general cleanup of the mine site area is recommended only where it is necessary to remove hazards such as acidic waste ponds, creeks with obvious transported waste material from the mine site, badly affected river banks where vegetation has not naturally regenerated, old structures, holding dams and the like that for a small cost can be cleared away to improve the aesthetic aspect of the area together with removal of potential health hazards.

The areas considered necessary for general clean up and soil treatment are:

- Surrounds beyond the toe of the reshaped Whites Overburden Heap.

- Surrounds to Dysons Overburden area once the heap has been substantially removed and reshaped.
- Surrounds to Whites North Overburden, once the heap has been removed.
- The Copper creek area where catchments exist from the copper heap leach pile. In this area the old launders and evaporation ponds should be removed, Copper Creek cleaned out, refilled and contoured, general regrading once the copper heap leach pile has been removed.
- Reshaping of the old haul roads to the north of Whites North area and the general area where the original heaps were located.

Refill and regrade erosion damaged area on the old treatment plant site.

Establish erosion protection berms on the slope and reseed areas where vegetation has been washed away.

Remove tailings waste transported down Tailings Creek, treat the soil and import new top soil, allow natural revegetation.

Remove transported wastes from the East Branch of the Finniss River down to the confluence of the Finniss River if necessary.

This exercise can only be determined at the end of the rehabilitation works, by inspection and decisions as to the extent of the remedial works shall be recommended once the affected areas have been identified.

Regrade and contour old borrow pits left exposed after completion of clean up works in 1979. A number of pits have not revegetated and should be cleaned up.

Remove the small ore stockpile at the eastern end of the old treatment plant site and dump into Whites Open Cut, before backfilling operations commence.

3.3.12 Rehabilitation of Borrow Pits and Haul Roads -

It will be necessary to rehabilitate all borrow pits used to win impervious clayey-gravels for overburden covers and topsoil for vegetation layers.

The main borrow pit area will be located 1.0 km south of Tailings Creek and the East Finniss Branch.

The pits will be opened up in rows of 100 metres wide using the coal strip mining techniques where the top soil, small trees and seeds would be pushed into a central windrow and once the pit has been stripped the top soil would be returned to allow natural revegetation.

Some reseeding may be necessary depending on the depth, area and location of borrow pits.

The total area once stripped will probably form a wide bowl in the area and will require final reshaping once all works have been completed.

It is now expected that all clays, gravels and topsoil can be found from within close proximity of the 200 hectare mine site, therefore confining the removal of further vegetation to the general mine site area which should be considered as a reasonable comprise when weighed against the total improvement over the same area.

All haul roads constructed during the project will be removed and regraded to suit the natural contours. The old roads will be tyned and fresh top soil added if necessary.

The roads around Whites Open Cut will require lime treatment and reseeding before the end of the project.

3.3.13 Protection Fence -

It is recommended to have an animal protection fence around the total site.

The revegetation programme has been designed to achieve rapid early soil stability using predominately native grasses. This will provide an attractive food source for buffaloes, kangaroos, wallabies, rabbits and other similar fauna known to habitate the area.

It will be necessary to fence the entire site and remove any of the aforementioned animals from the protected area before revegetation works commence.

SECTION 4

PROJECT COST ESTIMATES

4.0 PROJECT COST ESTIMATES

4.1. Summary of Costs

The measures proposed in this report have been estimated using current day rates for labour, plant, equipment and materials.

This section summarises the costs for each area of the rehabilitation works, in the same groups as previously presented in 'The Summary' and subsequently reviewed by the Commonwealth Department of Housing and Construction.

Notes relating to any assumptions made, sources of information, qualifications to the estimates that may affect its accuracy and other pertinent data have been listed in section 4.2.

A comparison summary between the $12M - 1980 dollars and this estimate will provide some reasons for the difference in costs from the previous reports.

It should be noted that the scope recommended in this report has changed in some of the areas and the water treatment plant is a totally different concept after proper investigation. Complete work sheet details of the estimate have been compiled into a separate file and will be made available to all interested parties.

4.1 Summary of Costs

PART A COMPARISON SUMMARY

Description	Strategy D-by D.H.C. - Feb. 1980 Dollars	Eng. Report May 1982 - July 1982 Dollars
Direct Costs		
Old Tailings Dam	2.75 M	0.832 M
Dysons Open Cut	0.16 M	0.161 M
Acid/Sweetwater Dams	0.29 M	0.191 M
Intermediate Open Cut	0.25 M (treat water)	Nil
Fence Site	0.22 M	0.024 M
Copper Heap Leach	0.54 M	0.478 M
Dysons Overburden	3.05 M	1.678 M
Whites Overburden	2.90 M	0.696 M
Whites North Overburden	0.50 M	0.328 M
Whites Open Cut	0.48 M (treat water)	0.386 M
Intermediate Overburden	0.87 M	0.217 M
Water Treatment Plant	- (Incl. in Whites & Intermediate O.C.)	5.837 M
Site Establishment	-	0.611 M
Site Services	-	0.415 M
Construction Camp & Accommodation	-	1.169 M
Other Areas - General Clean-up	-	0.333 M
TOTAL DIRECT COSTS	12.010 M	13.356 M
Indirect Costs		
Project and Construction Management	-	3.386 M
Contingency	-	0.550 M
TOTAL PROJECT COSTS	12.000 M	17.292 M
Estimate of $12 M escalated to July 1982 dollars		15.820 M
VARIANCE		($1.472 M)

PART B . DETAILED ESTIMATE - SUMMARY OF RECOMMENDED MEASURES

COPPER HEAP LEACH PILE

Dump Heap Leach Pile into Dysons Open Cut - 174,000m^3	423,000
Haul roads, top soil, cleanup - 16,000m^3	46,000
Vegetate surrounds	9,000
TOTAL	$478,000

TAILINGS DAM

Removal of Tailings to Dysons Open Cut - 240,000m^3	517,000
Top soil, drainage channels and reshaping - 90,000m^3	255,000
Vegetate tailings area	60,000
TOTAL	$832,000

DYSONS OPEN CUT

Haul roads - 3,000m^3	31,000
Impervious covers - 23,000m^3	66,000
Protection drains	30,000
Vegetate surrounds	34,000
TOTAL	$161,000

WHITES OPEN CUT

Connect Whites to Intermediate Open Cut	35,000
Pipeline Dysons to Whites Open Cut	119,000
Plug Whites with clay - 100,000m^3	200,000
Divert East Finniss River into Whites Open Cut	18,000
Crushed limestone for long term water quality - 5,000 tonne	14,000
TOTAL	$386,000

INTERMEDIATE OPEN CUT

Water treatment works only - see later summary	-
All cleanup of surrounds in other areas	-
TOTAL	NIL

DYSONS OVERBURDEN HEAP

Dump part of Heap into Dysons Open Cut - 722,000m^3 incl. haul roads	1,547,000
Dump Copper Heap Leach Pile into open cut - see previous summary	-
Reshape remaining heap - 214,000m^3	14,000
Impervious covers - 27,000m^3	82,000
Erosion protection drains	25,000
Vegetate heap - 4 H.a.	10,000
TOTAL	$1,678,000

WHITES OVERBURDEN HEAPS

Reshape Heaps - 90,000m^3	171,000
Impervious covers - 116,000m^3	327,000
Erosion protection drains	114,000
Revegetate surrounds - 52 H.a.	84,000
TOTAL	$696,000

WHITES NORTH OVERBURDEN HEAP

Haul roads and general cleanup	26,000
Dump Heap into Whites Open Cut - 151,000m^3	302,000
Vegetation in "other areas"	-
TOTAL	$328,000

INTERMEDIATE OVERBURDEN HEAP

Reshape Heaps - 20,100m^3	67,000
Impervious covers - 22,000m^3	66,000
Erosion protection drains	65,000
Vegetate heap - 8 H.a.	19,000
TOTAL	$217,000

ACID/SWEETWATER DAMS

Remove dam walls and clean out river bed	8,000
Rip all affected areas - lime treat - 55 H.a.	147,000
Build up river banks to contain flow - 8,000m^3	36,000
TOTAL	$191,000

OTHER AREAS

General cleanup of mine site areas, river courses and surrounds to overburden heaps	190,000
Remove small ore stockpiles from around mine site - 4,000m^3	16,000
Vegetation in same area	36,000
Removal of temporary facilities used during rehabilitation works	83,000
Remove copper launders - misc. structures	8,000
TOTAL	$333,000

WATER TREATMENT PLANT

Treatment plant	1,810,000
Borefield and delivery pipeline	503,000
Treatment plant operating costs	1,025,000
Lime consumption - 13,000 Tonne	2,499,000
TOTAL	$5,837,000

PROTECTIVE FENCE

10km animal proof fence	TOTAL	$ 24,000

SITE ESTABLISHMENT

Clear camp sites		16,000
Establish power, water and roads around mine site to camp/construction office/treatment plant		83,000
Establish borrow pits and push up top soil and gravel - 400,000m^3		311,000
Establish rip-rap pit - dozer ripping - 40,000m^3		58,000
Rip-rap pit - drill and blast - 3,000m^3		60,000
Construction management facility		39,000
Establish truck washing/workshop facility		44,000
	TOTAL	$611,000

SITE SERVICES

General labour for all areas		355,000
Misc. equipment (non earthmoving) hire		60,000
Construction management facility		-
	TOTAL	$415,000

CONSTRUCTION CAMP

Buildings and kitchen - 50 man		292,000
Camp services - power, water, sewerage		139,000
Camp generator fuel and maintenance costs		198,000
Camp accommodation		540,000
	TOTAL	$1,169,000

GRAND TOTAL DIRECT WORKS	$13,356,000

Engineering and Management Costs

Project and construction management		
	- labour	1,977,000
	- expenses	529,000
Soils consultants		276,000
Groundwater consultants		164,000
Other design services		156,000
N.T. Government divisions		
	Transport & Works - services	
	Transport & Works - water div.	
	Department of Health	
	Soils Conservation Commission	
	Lands Department	
	Treasury	284,000
	INDIRECTS COSTS TOTAL	$3,386,000
	DIRECT COSTS TOTAL	$13,356,000
	GRAND TOTAL	$16,742,000
	CONTINGENCY 5% on $11.0M (excluding water treatment plant)	550,000
	PROJECT TOTAL	$17,292,000

Estimate in July ~~1982~~ 1980 Dollars $12M

Escalated to July 1982 Dollars $15,820,000

VARIANCE	($ 1,472,000)

4.1. Summary of Project Estimates cont.

4.1.1 Proposed Changes to 'Strategy D' For Cost Reduction Purposes

The recommended measures put forward in this report should all be carried out in order to achieve the proposed level of pollution reduction considered appropriate by the Commonwealth Government.

The estimated costs in this report exceed the amount considered appropriate by the Commonwealth Government ($12M February 1980 dollars).

The additional costs can be justified because of the water treatment plant.

Previous reports have recommended further studies to resolve the complex problem of water treatment.

Now that a firm proposal has been put forward it is obvious that the original concept and projected costs $0.73M 1980 dollars was not adequate. The estimated cost put forward in this report is $5.837M. This one item is substantially greater than the budget variance.

Two options can be taken -

In the first instance it is recommended that the Commonwealth Government review the original estimates and increase the value of the project funds to accommodate the water treatment plant.

The rehabilitation strategy relies on the treatment of water to allow both Dysons and Whites Open Cut to be used for containment of other contaminants. If the concept of water treatment is rejected then so too must the rehabilitation strategy presented in 'The Summary' and this Engineering Report.

The other alternative is to reduce the scope of rehabilitation works taking the lowest priority items and deleting them from the project works. This and other suggestions have been listed below to permit cost reductions with the minimum impact on the higher priority rehabilitation objectives, those being:

(a) Finniss River Pollution

(b) Public Safety and Health Hazards

Residual Value of Plant and Equipment -

At the end of the project, a number of items would have a residual value if sold at auction. The revenue from the sale could be returned to the project funds as part payment for the additional costs needed to complete all works without any scope reductions.

An estimate of the residual costs of major equipment is given below:

Water Treatment Plant

Equipment - clarifier filter presses, pumps, lime handling equipment, conveyors, dust collectors and other plant items:	
Purchase Value $736,000	
Residual say 40%	$294,000
Tanks, clarifier shell, lime hoppers other usuable steelwork items:	
Purchase Value $335,000	
Residual say 30%	$101,000
Electrical switch boards and instrumentation:	
Purchase Value $205,000	
Residual say 25%	$ 51,000
Bore field pipework:	
Purchase Value $170,000	
Residual say 20%	$ 34,000
Construction camp:	
Purchase Value $300,000	
Residual say 40%	$120,000
TOTAL REVENUE FROM SALE	$600,000

If these residual savings can be used to offset the project costs then the balance of the variance

VARIANCE	1,472,000
RESIDUAL SAVINGS	600,000
NECESSARY SCOPE REDUCTIONS	$ 872,000

It is recommended to reduce only activities that relate to aesthetic improvement of the area in the first instance and possibly as a later measure, the deletion of the blinding clay and crushed limestone from Whites Open Cut which was only included for added long term assistance to the water quality. Its addition may not achieve any improvement.

Recommended Scope Reduction -

It was proposed to remove all affected soils in the Tailings Dam and spread 200 mm of top soil to assist rapid revegetation.

It is possible that the top soil may not be needed and by bulldozer ripping, lime treating and finally re-seeding the area, sufficient rehabilitation may be achieved.

The savings would be 70,000m^3 x \$2.00/m^3 \$140,000

The Acid/Sweetwater Dam area may rehabilitate with less work after the stream cleaning and removal of the dam walls has been completed. If restricted grading and revegetation is carried out in this area, possible savings may be in the order of \$120,000

Whites Open Cut - deletion of the clay blinding and limestone to be included for possible assistance in restricting further acidic action.

The savings would be \$214,000

Whites North Overburden - The possibility of Whites North Overburden achieving the desired effect of inhibiting pyritic action in White Open Cut may be suspect and when Whites Overburden has been covered it may reduce the source of pollution significantly.

The improvement in the aesthetics of Whites Open Cut surrounds may have to be less than expected to reduce costs.

By reshaping and covering Whites North Overburden, savings $200,000

TOTAL SAVINGS $674,000

To save a further $198,000 on direct scope reductions would reduce the overall effectiveness of the primary and secondary rehabilitation savings.

It would be difficult to choose other activities that could be deleted and still provide an overall satisfactory results.

The level of estimate confidence is considered to be -5% to +10%.

The contingency added to the project budget was 5% so it may be assumed that some savings in all sections of the project estimates may be possible.

Any further reductions to the scope would be minor in savings and not provide the necessary order of magnitude required to reach the $12M escalated costs.

The escalated factors to be applied after July 1st, 1982 should be the same for both past and present estimates. The project has been scheduled to have most of the work completed by the end of 1984, to achieve maximum benefits from the camp and management service costs.

In view of the reduced time, it may be proper to assume some savings on escalation as the project was predicted to be completed over a four year period.

4.2 Notes on Estimates

The project cost estimates have used a number of sources to gain all the necessary information.

In the time allowed it was not possible to confirm all data hence, it has been necessary to rely on quantities stated in other reports.

The assumptions included in the estimates were:

1. The quantities used in the estimate for overburden heaps were calculated using a computer digitising method which relys on the accuracy of the 0.5 metre contours of the area produced in 1977 by photogrammetry methods. It has been assumed that the overburden heaps have not been altered in shape since that time.

   The method of calculation should produce volumes within ±5% accuracy.

2. The volumes of water in the open cut pits have been taken from 'The Summary' - April 1978 page 68. Further confirmatory bathymetric surveys have not been carried out.

3. Local contractors provided current day equipment hire rates and contract rates for various types of activities.

   In each case the estimates were calculated using plant operating cycles to check the cubic metre rates given and in most cases the contract cubic metre rates were lower. The rates were normally adjusted up to allow for some additional degree of difficulty not allowed for.

4. All cubic metre quantities have been expressed in bank cubic metres. The relative tightness of each heap, particularly the copper heap leach was not known and a 1.3 swell factor was used to calculate the quantity of loose cubic metres to be shifted.

5. The results of the soils investigation indicate relatively deep borrow pits up to 2 metres deep. The swell factor assumed was 1.2 for all clayey gravel and top soil.

6. Appropriate labour loadings, in accordance with the industrial awards for uranium mining were added to the costs only for removal of the tailings material. Once the tailings have been dumped into Dysons Open Cut it is assumed that all work would be under normal construction industry awards.

7. The costs of revegetation were based on preliminary advice from the N.T. Soils Commission.

The rates used were:

Convential seeding:	$ 800/hectare
Hay mulch for side slopes	$5000/hectare

8. The protective perimeter fence has been designed as 1500mm high - 4 barbed fence strong enough to resist buffaloes. 'The Summary' report fence costs were substantially higher, indicating a 2.1 metre high manproof chain wire fence. It is not considered necessary to exclude personnel from the site.

9. The water treatment plant has been designed on parameters gained from laboratory testwork carried out by the N.T. Government Water Division laboratories. The samples used were taken from 2 metres below the surface.

The results gained were reviewed and compared with previous sampling some years earlier to ensure that sufficient design capacity was included for water that would have a higher concentration of metal ions and a lower pH. It is recommended that the current testwork be repeated on deep water samples before final design criteria is adopted for the water treatment plant.

10. Adequate groundwater data in the area does not exist in any past records.

To determine the capacity of the water treatment plant it was necessary to use the mining records provided by CRA as a guide to the inflow of water into the pit during mining. Some 2500m^3/day has been allowed in the plant design, which should be less given the present hydraulic head applied to the pit by the water in each open cut.

The quality of the groundwater coming into the pit has been taken as pH.6 for the purposes of calculating lime consumption.

11. The excavations for the Whites/Intermediate Open Cut connection channel has been taken as rippable rock by a D8 bulldozer.

12. The use of scrapers for the works was taken into account, however their restricted versatility may cause an overall more costly exercise.

The type of activities have been carefully selected to allow year round work through both wet and dry seasons to minimise the supervision and administration costs. The scrapers have a great benefit in shifting clay and topsoil, but cannot be economically employed to shift the rock. It was decided to use a predominately $20m^3$ semi tippers, 35 tonne payloader haul trucks and front end loaders, so that year round versatility can be achieved.

13. The construction camp and site administration office will use second hand units presently available around Darwin. There is no guarantee to the length of time of availability.

14. The 400 KVA generator for the water treatment plant has been assumed to be free supply from the N.T. Government cyclone standby units presently stored in Darwin.

15. Alternatives to site camp accommodation were investigated. The use of Batchelor facilities was not favoured by the authorities using the town for aboriginal training. The costs and time to travel each day to Darwin ruled out another option. It would also affect productivity when shifting the major stockpiles and overburden heaps.

16. Previous correspondence with C.R.A. has confirmed that the copper heap leach can be disposed of without any compensation payment due.

17. The management team proposed for the project would be assembled from N.T. Government personnel assigned to the project together with services from private industry to assist with detailed design and construction supervision.

The N.T. Water Division and Soils Conservation Commission would provide major contributions to the project works.

Costs for all Government officer salaries, expenses and incidentals have been included in the management estimates.

18. The costs to reticulate the revegetated areas has not been included as the advice given by the Soils Commission would indicate successful growth should be achieved if seeding and hay mulching is carried out between October and December each year.

19. The order of accuracy of the estimate is considered to be -5% +10% with the exception of the water treatment. It's level of confidence is +10%. Appropriate contingency factors have been added to the project estimates.

4.3 Cash Flow Projections

The cash flow projections have been based on the project schedules included in Section 5 of this report.

Two cash flow charts have been included:

(a) The total project cash flow chart commencing October 1st, 1982 until December, 1985.
(b) Summary of 1982/1983 costs.
(c) A cash flow chart for the 1982/1983 activities commencing October 1st, 1982 until June 30th, 1983.

The escalation applied to the project costs from July, 1982 has been estimated at 0.9%/month.

PROJECT CASH FLOW

DATE	JULY 1982 EST. COSTS	ESCALATION	TOTAL CASH FLOW
1982			
SEPT			
OCT	80	0	80
NOV	195	2	197
DEC	405	7	412
1983			
JAN	529	14	543
FEB	518	19	537
MAR	445	20	465
APR	285	15	300
MAY	650	41	691
JUN	873	63	936
JUL	730	59	789
AUG	670	60	730
SEPT	700	69	769
OCT	500	54	554
NOV	460	54	514
DEC	400	50	450
1984			
JAN	380	51	431
FEB	480	69	549
MAR	402	62	464
APR	450	73	523
MAY	460	79	539
JUN	460	83	543
JUL	610	115	725
AUG	760	150	910
SEPT	750	155	905
OCT	1,000	216	1,216
NOV	1,030	232	1,262
DEC	600	140	740
1985			
JAN	300	73	373
FEB	240	60	300
MAR	280	73	353
APR	260	70	330
MAY	260	73	333
JUN	260	75	335
JUL	400	119	519
AUG	220	67	287
SEPT	80	25	105
OCT	80	26	106
NOV	70	23	93
DEC	20	7	27
TOTAL	17,292	2,643	19,935

* N.B. All dollar values x 1,000.

4.0. PROJECT COST ESTIMATES cont

4.1 Summary of Costs for 1982/1983 Programme

DIRECT WORKS		JULY 1982 COSTS	
Site Establishment -		356,000	
Construction Camp -			
	Camp buildings	292,000	
	Camp services	139,000	
	Construction management offices	39,000	
	Camp operating charges	80,000	
	Camp accommodation	100,000	
Tailings Dam -			
	Remove tailings to Dysons	613,000	
	Reshape,protection drainage and top soil to tailings dam		
Whites Overburden Heap -			
	Reshape Heaps	120,000	
Treatment Plant -			
	Design	190,000	
	Part supply of equipment	500,000	
	Borefield installation	304,000	
		TOTAL DIRECTS	2,733,000
INDIRECTS			
	Soil consultant	140,000	
	Groundwater consultant	163,000	
	Other design services	50,000	
	N.T. Government services	105,000	
	Project Management/Admin.	600,000	
		TOTAL INDIRECTS	$1,058,000
	GRAND TOTAL JULY 82/JUNE 83		$3,791,000
	5% contingency		189,000
	TOTAL		$3,980,000

1982/1983 WORKS PROGRAMME CASH FLOW

DATE	JULY 1982 EST. COSTS.	ESCALATION	TOTAL CASH FLOW
1982			
SEPT			
OCT	80	0	80
NOV	195	2	197
DEC	405	7	412
1983			
JAN	529	14	543
FEB	518	19	537
MAR	445	20	465
APR	285	15	300
MAY	650	41	691
JUN	873	63	936
JUL			
AUG			
SEPT			
OCT			
NOV			
DEC			
TOTAL	3,980	181	4,161

* N.B. All dollar values x 1,000.

SECTION 5

TIME FRAME FOR UNDERTAKING THE WORK

5.0 TIME FRAME FOR UNDERTAKING THE WORK

Project Execution

The Project schedules in this section of the report indicate the planned activities for the overall project extending from October 1st, 1982 until December 1985.

A more detailed schedule for the period October 1st, 1982 until December 1983 has been included to provide more details of the first years operations and highlight the independency of activities and the effect on the overall project duration if the commencement of the project is delayed.

General

The project activities have been carefully selected to suit the dry and wet season conditions in the area.

The costs to mobilise heavy earthmoving equipment is considerable and by maintaining activities all year round, the plant will be better utilized and the camp costs can be reduced by keeping more average numbers of men rather than peak crews in the dry season and small crews in the wet season.

The supervision and project management costs can be more effectively used by minimising the overall project time. By working through each wet season, it reduces the overall time scale by some eight months.

To gain maximum benefit from the vegetation programme it is advisable to carry out hay mulching of slopes and conventional seeding of flat areas during October to December periods.

The approach taken in respect to detailed design of the various activities is to design and specify only the overburden heaps including reshaping, impervious covers and shifting of large discrete heaps.

The remaining works such as rehabilitation of river beds, general mine site cleanup, removal of copper launders and evaporation ponds, revegetation works and removal of minor heaps will be supervised by the site team with some broad specifications provided.

It is the objective of the project task team to maximise the use of a plant hire team rather than expending costs in engineering design and specification except where a benefit in arranging specific contracts can be determined.

It will require more site supervising so day to day decisions and directions to contractors can be adequately dealt with. It is expected to achieve more direct rehabilitation of the site rather than detailed design and documentation.

Plan of Execution on 1982/1983

- Project Approval by Commonwealth Government by September 1982.

- Formation of project team.

  The team will be formed under the direction of the N.T. Transport and Works - Water Division.

  It will consist of experienced project staff, some drawn from the participating Government departments.

- Office space in Darwin will be allocated to the team and all services such as telephone, telex to the site established soon after.

  By reducing the amount of offsite engineering to a minimum, communications with the site is critical.

- A site management office will be established at Rum Jungle, adjacent to the existing storage sheds located near Whites Open Cut. It will be situated away from the tailings area for health and safety reasons.

- A 50 man camp will be constructed 1 km to the north of the Tailings Dam near the site where the last camp in 1979 was situated. Old water bores exist in the area which need minor cleaning and new bore pumps to re-establish a reliable fresh water supply.

  The cost of establishing a camp is considerable over the 3 year period. Alternative proposals were investigated. These included a camp/caravan park in Batchelor.

The town management were not in favour of the facility being in Batchelor and would only permit a camp at Rum Jungle South or Rum Jungle. There was not sufficient other accommodation available.

Diesel generating sets will be required for the camp and the treatment plant. The cost to refurbish the overhead line back to Batchelor is $118,000 and cannot be considered an economical prospect.

- It will be necessary to set up site laboratories for water sampling and soils testing. Results from the tests will be used to control selection of overburden cover material, the operation of the water treatment plant, and the allowable water release to the East Finniss River.

  Once all project office facilities have been established by March 1983, it is intended to commence the first major rehabilitation activity.

Tailings Dam Removal -

The tailings must be carefully removed to Dysons Open Cut. It is considered appropriate to carry out the works on a schedule of rates basis. The haul road will be established by the hourly rate, plant hire crew who would carry out all activities on an "as directed" basis. The tailings should be removed in 10 weeks and the period has been selected to take advantage of a low water table under the Tailings Dam.

After all tailings have been removed approximately 200 mm of acidic soils under the tailings will be taken away to Dysons Open Cut.

A natural river course will be formed to control water flow through the area during the first wet season to prevent scouring of large exposed areas.

Topsoils, protection berms, drainage channels and revegetation of the Tailings Dam is expected to be completed between May and December 1983, due to coincide with the dry season.

The water displaced in Dyson Open Cut must be removed before the rock fill can be placed over the tailings. This activity is dependant on the water treatment plant being in operation by January 1984.

Whites Overburden Heap -

The detailed design of the main overburden heaps will be completed by January 1983. A suitable contractor will be selected by April 1983.

Reshaping can be carried out during the wet season without difficulty and it is expected to complete Whites Overburden Heap including impervious soil covers between April and September 1983.

Revegetation is scheduled for completion by December 1983 prior to the 'growing' season.

Moving of the tailings and rehabilitation of Whites Overburden are the two major site activities planned for 1982/1983 once all project and construction facilities have been established.

Engineering Investigations -

The detailed engineering and investigations works recommended in the 1982/1983 programme are:

1. Detailed Design of Dysons,Whites and Intermediate Overburden covers using naturally occuring clayey - gravels, rip-rap and suitable top soils.

2. Detailed design and procurement of the water treatment plant -

The operation of the treatment plant is the key to a number of other major activities planned for 1983/1984. Some of the equipment will take 30 weeks to manufacture and deliver hence, the importance to commence design work in October 1982.

3. Water Injection Investigations -

The removal of treated water from the site remains the one major concern at the time of this report. The method of disposal cannot be decided upon until trial test bores have been established and the pumping rates confirmed.

The method of injection is not an unproven technique. The geology of the area and the records of water flow indicate the prospects of success very high. It is necessary to intersect a high flow aquifer, establish the pumping rates and the head needed for pump design. The costs of the drilling works has been calculated by the N.T. Water Division on their success ratio when establishing new bore fileds. By careful selection of the proposed site, it may be possible to reduce the drilling costs.

The costs of casing and other permanent materials will be used for the final water treatment plant disposal system.

The method of disposal is independent of the treatment plant and any changes could not effect the recommendation to design and construct a continuous water treatment plant as proposed in this report.

Other works planned for the first year are:

1. Establishment of stream gauging and sampling stations around the site.

2. Stripping and establishment of borrow pits.

3. Establishment of rip-rap borrow pits.

4. All weather haul roads around the mine site.

Programme of Works 1982 to 1985.

It is expected to complete White and Intermediate Overburden reshaping by June 1984 and all revegetation by December 1984.

Completion of Dysons Open Cut filling and reshaping is expected by December 1984 owing to water treatment restrictions.

Removal of the copper heap leach is expected to commence in February 1984 once the water treatment commences operation.

Whites North Overburden will be shifted late 1984 after all water from Dysons has been treated.

The aesthetic rehabilitation of the Acid/Sweetwater Dam, areas under heaps removed to Whites Open Cut, cleaning of river courses, general recontouring of local mullock heaps have been scheduled as the last major activity between March and July 1985.

The amount of work to be done in this area is difficult to assess at this stage. Some other rehabilitation activities may reduce the amount of work planned. An assessment of final cleanup works is needed by late 1984.

All aesthetic rehabilitation and revegetation programmed will be completed by daily hire equipment crew, supervised by the site project team.

The vegetation programme will be co-ordinated by the N.T. Soil Conservation Commission and has been scheduled for the latter part of 1983 and 1984.

The success of the revegetation programme will be monitored during two wet seasons and it is expected to need remedial work carried out on areas that have not shown signs of regrowth or have been damaged by erosion.

A four month evaluation and remedial works programme has been included as a realistic contingency.

In 1985 it is anticipated to complete aesthetic rehabilitation of the mine site area, removal of haul roads, recontouring of borrow pits, remedial work to new vegetation areas and completion of the open cut water treatment programme.

Once the water treatment has been completed by September 1985, the only remaining activities are -

- Diversion of the East Finniss River into Whites Open Cut
- Removal of the treatment plant
- Removal of the camp
- Removal of the construction management offices and services
- Rehabilitation of all areas used for plant and accommodation.

Check all monitoring stations to ensure all are operational.

Complete all accounting and administrative functions in Darwin.

Complete a project report outlining all activities undertaken and the measured success of the project at time of completion.

Long Term Monitoring -

Methods proposed for a long term monitoring programme will incorporate stations installed before and during the course of the rehabilitation programme:

The programme is discussed in more detail in Section 6 of this report.

In brief it will consist of the four stream gauging and water sampling stations set up on the:

- East Branch of the Finniss River (1)
- Tailings Creek (1)
- Finniss River (2)

The 10 observation bores needed for ground water injection sampling will be a permanent feature for monitoring long term groundwater arising from the adjacent open cut pits.

Monthly sampling of the open cut water would be desirable for approximately, 3 years during 'settling down' period.

Photography of fixed vegetation plots on overburden heaps and the Tailings Dam Site would be beneficial to establish the rate of revegetation progress.

A 35 mm colour movie would be beneficial showing 'before', 'during' and 'after' conditions.

The 'before' scenes have already been taken during November 1981.

The project schedules for all works and for the 1982/1983 period have been included in Section 5.3 of this report.

5.2 Project Organisation

The project organisation chart has identified all key positions needed to carry out the main functions during the course of the project.

It is proposed that the Director of the Water Division would act as project director and a controlling committee comprising the Secretary of the Transport and Works, other senior N.T. Government officers and nominated Commonwealth officers would meet on a regular basis to review engineering proposals, receive progress reports on achievements and expenditure forecasts.

The project co-ordinator would supervise all activities on a full time basis to ensure achievement of the project objectives.

Some specific assistance from consultants is recommended to provide expertise in determining:

(a) design of the water treatment plant
(b) ground water evaluation of water injection bores
(c) soils testing and control of compaction, identification of the correct material from borrow pits and detailed design of the impervious overburden covers.

It is proposed to use a number of N.T. Government Departments to assist in:

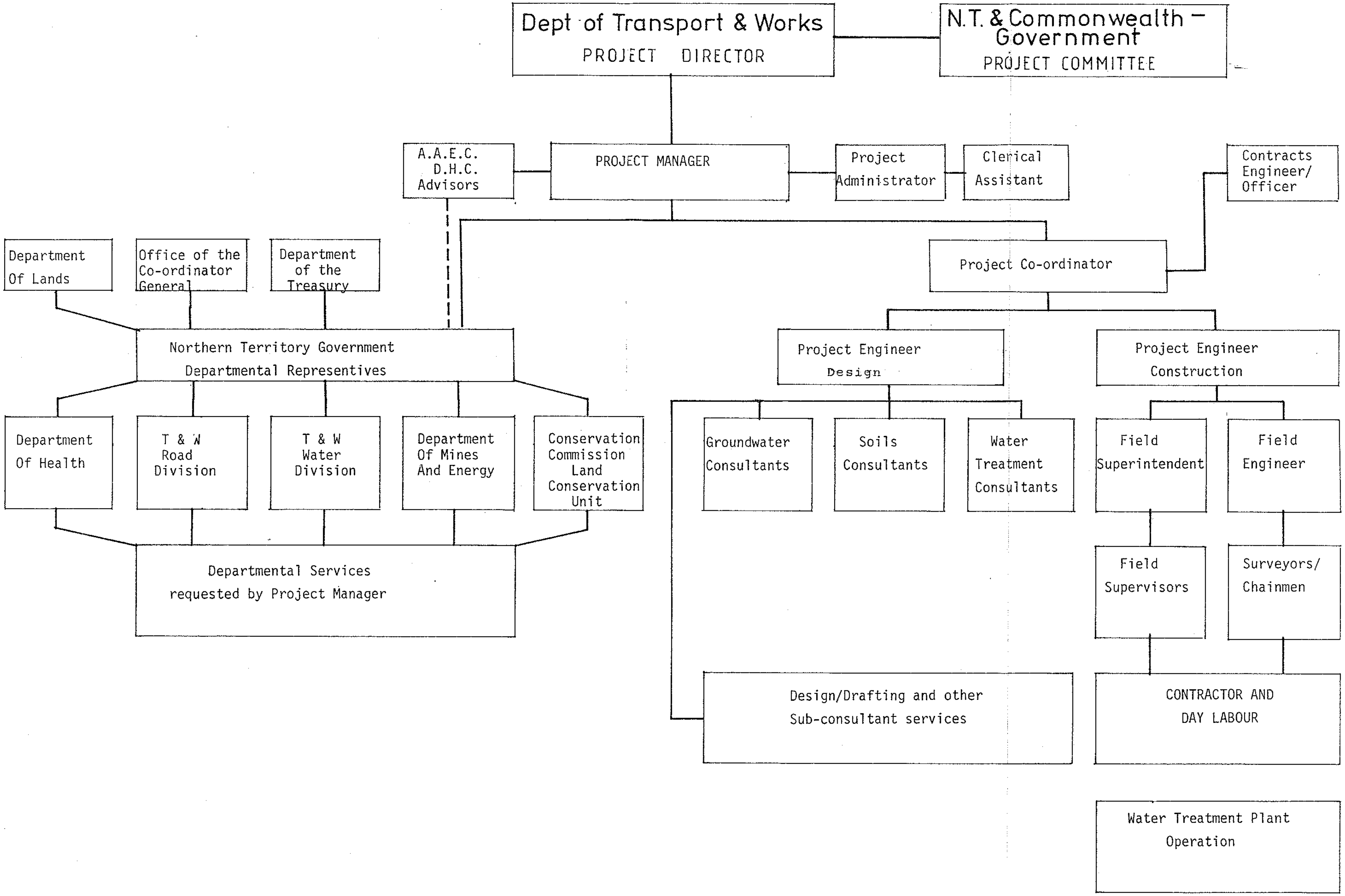
water quality sampling
laboratory analysis
vegetation programmes
radiological survey
land survey
bathemetric survey
ground water drilling and pump testing

An assignment chart has indicated the duration of the key project team members.

The final works in 1985 has a small supervisory team to minimise costs, as water treatment is the major activity.

The final cleanup works should be carried out with a small crew and it may be possible to complete the 1985 works using Darwin and Batchelor for accommodation rather than a camp.

ORGANISATION CHART Rum Jungle Rehabilitation Project



MAY 1982

ASSIGNMENT CHART — Rum Jungle Rehabilitation Project — MPES

duration / function	1982 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	Mhr's
COMMITTEE REP (1)					X		X		X		X		X		X		X		X		X		X		X		X		X		X					X					X		600
PROJ. MGR.				X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	1,300
PROJ. CO-ORDN.				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-	-	X	10,100
CLERICAL ASSIST.				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X													6,300
PROJ. ADMIN.				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	6,700
PROJ. ENG. ENGINEERING				X	X	X	X	X	X	X	X	X	X																														1,700
PROJ. ENG. CONSTRUCTION							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X													5,100
CONTR. ENG.				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												4,400
CONTR. OFFICER				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												4,600
FIELD SUPERINTENDENT				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8,200
FIELD ENGINEER												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X										3,300
FIELD SUPERVISORS				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X										10,000
SURVEYORS				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X													5,700
CHAINMEN				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X													5,700
TREATM. PLANT OPERATORS																		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					30,600
FIELD ASSIST.							X	X	X	X	X						X	X	X	X	X	X	X						X	X	X	X	X	X	X								8,400
GENERAL HANDS (3)				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								19,000
RADIATION OFFICER						X	X	X	X	X	X	X																															1,400
ENG. CONSULT.				X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X																			-
SOIL CONSULT.				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X													-
WATER CONSULT.				X	X	X				X	X	X																															-
TREATM. CONSULT.				X	X	X	X	X	X	X	X	X	X	X	X	X																											-
GOVERN. DEPTS				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

X - - - - - - - - X PART TIME SERVICES

Total 133,100

RUM JUNGLE REHABILITATION PROJECT

ENGINEERING REPORT

MAY 1982

VOLUME II   SOIL STUDIES

PART 1

RESULTS OF SITE INVESTIGATIONS

Mining & Process Engineering Services

RUM JUNGLE REHABILITATION PROJECT

RESULTS OF SITE INVESTIGATION

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RUM JUNGLE REHABILITATION PROJECT

RESULTS OF SITE INVESTIGATION

1. INTRODUCTION

This portion of the report presents the results of the site investigation and materials study undertaken at Rum Jungle during April and May 1982.

The site is located approximately 100 km south of Darwin by road and 9 km north of Batchelor. The area examined during exploration surrounds the abandoned Rum Jungle Mine Site and is shown on Figure 1.

Properties of potential construction materials were assessed by field sampling and laboratory testing at the site. A laboratory was established at Rum Jungle in facilities provided by the Department of Transport and Works, Water Division, specifically for the Project.

2. SITE INVESTIGATION

2.1 Investigation Criteria and Exploratory Programme

This field study was undertaken to determine the types and amounts of naturally occurring materials available on-site and allow engineering design of rehabilitation measures.

Materials are required for construction of engineered covers over various contaminated areas and for rehabilitation of the entire site. Sources of borrow would desirably be:

* Deep deposits to reduce the impact of excavation on undisturbed areas

* Close to the site to provide economical haul distances

* Located on topographic highs to allow drainage and prevent ponding from rainfall.

After initial site visits were made, an exploration programme comprising 64 backhoe excavated test pits was undertaken. These pits, normally 3m to 4m in depth, were positioned to gain the maximum information with a limited programme rather than excavated on a regular grid. The area investigated covered 9 square kilometres.

Samples taken from the backhoe pits were tested at the site soils laboratory established as part of the investigation. This allowed the exploration programme to be adjusted during the investigation and thus avoid major areas of uncertainty.

Test pit locations are shown on Figure S1.1 and a compilation of test pit logs is contained in Appendix A below.

2.2 Site Geology

The investigation area comprises a gently undulating plain, rising to a minor escarpment immediately north of the site.

Rum Jungle Granite surrounds the site to the south, east and north while the mine site and the adjacent western area comprise sediments of the Pine Creek Geosyncline. These sediments include dolomites, mudstones and conglomerates. From the Geological Plan (Figure S2.2) it can be seen that tectonic activity has produced major faulting and quartz intrusions.

The soils overlying the Rum Jungle Granite have resulted from insitu weathering of the granite and are essentially sandy gravels and gravelly sands. This material does not exhibit significant lateritisation and only supports a sparsely vegetated cover.

In contrast, material overlying sedimentary formations is highly laterised with significant clay fractions and supports a medium to very thick vegetation cover. The area drains to the west along the Finniss River.

2.3 Generalised Soil Profiles

As mentioned above, the materials overlying sedimentary formations are highly laterised. These soils have a generalised profile comprising either:

* 0.1 metres of clayey sand rich in organics

* 3.5 metres of loose to medium dense laterite and soft to stiff lateritic clay

or

* 0.1 metres of clayey sand rich in organics

* 2.0 metres of lateritic gravel

* 1.5 metres of lateritic clay

Soils derived from granitic material generally comprise:

* 0.1 metres of sandy gravel with some organic matter

* 1.0 metres of loose to medium dense sandy gravel

* 0.5 metres of medium dense to dense clayey gravelly sand.

Both profiles terminate on extremely to moderately weathered rock.

3. CONSTRUCTION MATERIALS

Suitable construction materials encountered during this investigation can be classified into six broad types according to their properties and potential utilisation.

The following discussion describes the basic properties of these materials, and their potential uses.

3.1 Topsoil

Topsoil is required in almost all areas of the proposed rehabilitation to provide a seed bed. Suitable material for topsoil was encountered in the majority of test pits located to the west and north of the mine site. This material comprises a surficial layer between 0.1m and 0.4m deep of fine grained, brown clayey sand of loamy appearance containing significant amounts of roots and organic matter. It normally overlies a fine grained, red clayey sand which extends to between 1.0m and 1.4m depth, although in some areas the topsoil type material extended to a depth of 1.5 metres.

The proposed topsoil material is generally loose and would be easy to excavate after vegetation stripping.

3.2 Lateritic Clays

Composed of sandy clay of high plasticity, these lateritic materials were encountered in the vicinity of the test pits RJ19 to RJ23, RJ37 to RJ39, RJ45 to RJ51 and RJ60. The lateritic clays extended to a depth of up to 3.5m and were generally moist with a consistency in the range of firm to stiff and thus would present no problems during excavation if kept well drained.

Figure S3.1 presents the grading envelope and plasticity characteristics of the lateritic clays. This material could be compacted in dense impermeable layers which would accommodate movement without cracking. If used for construction, the layers would require protection to prevent erosion.

3.3 Laterites

Laterites were encountered in the vicinity of test pits RJ1 to RJ10, RJ19 to RJ20, RJ26 to RJ30, RJ36 to RJ44, RJ52 and RJ57. The laterites consisted of fine to coarse grained clayey sands and gravelly sands with clay fines of low to medium plasticity. The density of the laterites was found to vary from loose to very dense and would generally be very easy to excavate. The grading envelope and plasticity characteristics of the lateritic sands are presented in Figure S3.2.

This material would provide semi-impervious, well compacted layers. Some protection would be required to provide adequate resistance to erosion by overland flow.

3.4 Lateritic Gravels

Lateritic gravels were found to consist of fine to medium grained sandy gravels and clayey gravels with clay fines of low to medium plasticity. The lateritic gravels were encountered generally within a depth of 2m in the vicinity of test pits RJ1 to RJ7, RJ14 to RJ15, RJ37 to RJ51, RJ56 and RJ60. Figure S3.3 presents the grading envelope and plasticity characteristics of the lateritic gravels.

Two distinct types of lateritic gravels were encountered. Most abundant were poorly graded gravels of essentially uniform particle size. This material would be suitable for capping of overburden heaps and provide a semi-impervious layer of well compacted material with sufficient clay content to bind the gravel particles together. The resulting layer would be resistant to erosion from overland flow.

The second type of gravel was encountered near the downstream end of the tailings area. This deposit was easily accessible and contained well graded sandy gravels with considerable clay that would be suitable for road construction.

3.5 Extremely Weathered Granite

Soils of granitic origin were encountered in the vicinity of test pits RJ13 to RJ14, and RJ27 to RJ32 to the south east of the mine site. The soil profile developed over the granite was found to consist of fine to coarse grained clayey sands and fine grained sandy gravels which extended to a depth of 2.5m. These soils were found in a dry to slightly moist state and were medium dense to very dense. Clay fines of the extremely weathered granite were of medium plasticity. The grading envelope and plasticity characteristics of this material are presented in Figure S3.4.

Generally, this material was found to be porous in nature and lacking in sufficient nutrients to support significant vegetation.

When compacted in layers, it would form well graded, pervious to semi-pervious material and be suitable for filter and transition filter zones.

3.6 Rock

Sound rock, suitable for use as rip-rap, is required for erosion protection measures. Rock outcrops in the area are confined to large quartz reefs and the minor escarpment north of the site. As described in 3.5 above, granite is available close to the site at a depth of 2m.

The quartz reefs have been rejected as construction material due to their limited extent and the visual impact that removal would cause.

Hence material suitable for use as rip-rap, apart from clean rock contained within the overburden heaps, is limited to the granitic areas south and east of the site, the escarpment area north of the site and minor gravel deposits in stream beds. The river gravels are composed of sound rock and, when used in gabion structures, would be aesthetically pleasing.

The granite would first require excavation of 1.5 metres to 2.0 metres of overburden followed by a drill and blast operation to obtain significant quantities but has the advantage of short haul distances.

It is uncertain whether excavation of escarpment material would require drilling and blasting but, although the haul is downhill, the haul distance is further than for the granite.

4. LOCATION AND DESCRIPTION OF BORROW AREAS

The locations of five potential borrow areas to provide construction materials required for the rehabilitation works are shown on Figure S4.1, while Table 4.1 details the estimated quantities of material available in each area.

Borrow Area 1 is located adjacent to the western edge of the main Batchelor Road and is presently open grassland with occasional trees to 10m height. The borrow area is suitable for the winning of topsoil, laterite and lateritic clay using load/haul or scraper operations. The haul distance to the Intermediate Open cut is about 1.5 km and to White's Open Cut is 2.0 km. The grading and plasticity characteristics of the lateritic clays encountered in this area are shown on Figure S4.2. Drainage of Borrow Area 1 would be south into an easterly flowing creek which runs into Wandering Creek.

Borrow Area 2 is located north west of the Batchelor Road and is presently heavily vegetated with many trees up to 25m in height. Topsoil, laterite and lateritic gravel can be won from this area again using load/haul or scraper operations. Haul distances to the Intermediate Open Cut are about 1.0 km and to White's Open Cut about 1.5 km. The grading and plasticity characteristics of the laterite and lateritic gravel encountered in this area are shown on Figure S4.3. The drainage of Borrow Area 2 is into the Finniss River East Branch.

Borrow Area 3 is located to the north west of the main mine site and is presently heavily vegetated with several trees up to 10m high. Some scrub clearings are present. Construction materials available from Borrow Area 3 include shallow deposits of gravelly clay overlying lateritic clay. The grading and plasticity characteristics of the winnable materials are presented in Figure S4.4. Haul distances for scrapers or dump trucks would be about 0.7 km to the Intermediate Open Cut and 1.2 km to White's Open Cut. Drainage of Borrow Area 3 would be to the north into the Old Tailings Creek and to the west into Finniss River East Branch.

Borrow Area 4 is located adjacent to the north of Dyson's Open Cut and Overburden Heap. The Borrow Area would provide both laterite and lateritic gravel for rehabilitation works on Dyson's Open Cut with a haul distance of about 0.6 km. The grading and plasticity characteristics of these laterites and lateritic gravels are presented in Figure S4.5. Borrow Area 4 is presently scrub land with several trees to 10m height. Drainage is to the east into a creek feeding the Finniss River East Branch.

Borrow Area 5 would provide a source of sand and sandy gravel derived from extremely weathered granite and, below about 1.5 to 2.0m, relatively fresh granite. The Borrow Area is presently grassland with several trees to 10 m height. Material could be removed by bulldozing and ripping. However, rock-fill derived from the underlying granite would need to be won by drilling and blasting. The haul distance to White's Overburden is about 0.5 km, to Intermediate Open Cut about 0.5 km and to Dyson's Open Cut about 2.0 km. Drainage of Borrow Area 5 would be north into the Finniss River East Branch.

BORROW AREA NO.	ESTIMATED AREA (m2)	MATERIAL TYPE	AVERAGE THICKNESS (m)	AVAILABLE VOLUME (m3)
1	140,000	Laterite (SC)	0.5	70,000
		Lateritic Clay (CH)	2.5	350,000
2	140,000	Lateritic Gravel (GP-GC)	2.0	280,000
3	137,000	Lateritic Gravel (GC-GS)	1.7	232,000
		Lateritic Clay (CH)	1.0	137,000
4	45,000	Sand (SP)	1.0	45,000
		Granite (Rockfill-blast as Required)		
5	200,000	Laterite (SC)	0.5	100,000
		Lateritic Gravel (GC)	1.0	200,000
		Lateritic Clays (CH)	1.5	300,000

TABLE 4.1 - ESTIMATED BORROW PIT QUANTITIES

5. REQUIREMENTS OF FURTHER TESTING

The current exploration and testing programme was sufficient to delineate the principal material types to be found in the area and allow designs to be formulated.

However, before proceeding with construction, it will be necessary to undertake the following tasks:

* Selection and proving of final borrow areas for the range of material types appropriate to the requirements of the design.
* Detailed investigation of rip-rap sources to select the most economically suitable material.
* Identification of inert material within the existing Overburden Heaps which would be suitable for construction.

Successful functioning of the rehabilitation measures is dependent upon correct construction placement. This placement can only be guaranteed by an appropriate quality control programme to monitor construction and if necessary facilitate design modifications.

6. FIELD PROCEDURES AND SUMMARY OF LABORATORY RESULTS

6.1 Test Pits

In order to investigate and sample the uppermost 4.0 metres of the sub-surface beneath the site, a John Deere backhoe was used for excavating test pits. Each pit was approximately 4.0 metres long and 0.6 metres wide and was taken to the maximum depth capacity of the machine, or to refusal, generally 3.0 to 4.0 metres. The exploration comprised a total of 64 pits.

The excavation of each test pit was supervised by a Geotechnical Engineer, who examined, logged and sampled the sub-surface materials. Each pit was then backfilled.

Test pit sample locations were chosen to provide a representative range of foundation and construction materials. Bulk samples of layers in the soil profile were obtained from the sides of test pits making sure to include the entire depth of the layer as defined in test pit logs. A total of 84 bulk samples were taken, of which 70 were selected for laboratory analysis.

6.2 Laboratory Testing

All laboratory testing was conducted in accordance with Australian Standard 1289 - METHOD OF TESTING SOILS FOR ENGINEERING PURPOSES, and results obtained from testing are summarised in Tables 6.1 and 6.2

The following tests were conducted during the investigation:

Test	Procedure
Determination of Soil Moisture Content	AS 1289 B1.1 - 1977
Determination of Liquid Limit	AS 1289 C1.1 - 1977
Determination of Plastic Limit	AS 1289 C2.1 - 1977
Calculation of Plasticity Index	AS 1289 C3.1 - 1977
Determination of Linear Shrinkage	AS 1289 C4.1 - 1977
Particle Size Distribution (Standard Method)	AS 1289 C6.1 - 1977
Particle Size Distribution - Analysis by Sieving in Combination With Hydrometer Analysis	AS 1289 C6.2 - 1977
Maximum Dry Density - Standard Compaction	AS 1289 E1.1 - 1977
Maximum Dry Density - Modified Compaction	AS 1289 E2.1 - 1977
Emerson Class Number	Draft Standard DR 79081

Pit No	Depth (m)	Sample No.	Geological Profile	USCS Symbol	Particle Size Distribution % of Total Dry Weight Passing B.S. Metric Sieve – Microns 2	10	50	75	150	300	425	600	Millimetres 1·18	2·36	4·75	9·5	19·0	37·5	63·0	As Received δ d t/m³	N.M.C %	Atterberg Limits WL	IP	Linear Shrink %	Compaction Stand. MDD t/m³	OMC %	Modif. MDD t/m³	OMC %	Emerson Class Number
RJ 1	2.1-3.0	30501	Laterite	SP-SC				10	17	27	32	38	47	58	68	85	98	100			20	43	23	8					
RJ 1	1.0-2.1	30502	Lateritic Gravel	GC	8	11	14	16	22	27	29	31	34	41	56	72	82	100			12	40	23	10					5
RJ 1	0.1-1.0	30503	Laterite	SC				24	40	58	65	73	81	87	92	94	95	100			9	30	17	7					
RJ 2	0.1-2.3	30504	Lateritic Gravel	GW-GC				10	14	18	19	20	22	29	52	79	93	100			7	40	7	10					
RJ 2	2.3-3.5	30505	EW Rock	GW				3	5	8	10	13	18	26	30	40	55	86	100		8								
RJ 3	0.1-1.5	30506	Lateritic Gravel	GC				15	16	18	19	21	22	27	42	63	86	92	100		8	32	18	9	2.45	10.0			
RJ 4	2.8-3.2	30507	Lateritic Gravel	GC				12	16	22	24	27	32	41	69	96	100				16	37	16	6					
RJ 4	0.2-2.8	30508	Laterite	SC				29	42	59	65	73	83	92	98	99	100				17	43	27	11					
RJ 5	1.7-2.1	30509	Lateritic Gravel	GW				4	6	8	9	10	13	19	51	89	92	92	100		13	37	21	6					
RJ 5	0.1-0.8	30510	Laterite	SC				19	31	45	49	54	60	67	79	94	100				10	35	21	11					
RJ 6	0.4-1.7	30511	Laterite	SC				23	41	63	73	84	94	98	99	100					17	41	25	10					
RJ 6	2.9-3.5	30512	EW Rock	SC				15	25	40	49	60	73	84	90	96	100				17	37	18	8					5
RJ 7	0.2-0.8	30513	Laterite	SC				19	33	52	61	73	85	93	98	100					12	27	23	10					
RJ 7	1.6-3.2	30514	EW Dolomite	GC				12	19	25	28	32	36	45	67	85	96	100			11	41	26	8					
RJ 7	0.8-1.6	30515	Lateritic Gravel	GC				12	21	29	32	36	39	42	45	51	57	73	73		12	32	21	6					
RJ 8	0.2-4.0	30516	Laterite	SC				19	35	57	67	80	91	97	100						18	41	24	10					
RJ 10	1.0-1.7	30517	Laterite	SC				17	28	46	52	59	66	73	78	87	94	100			13	39	26	9					
RJ 11	0.1-1.0	30518	Alluvium	SC				22	37	53	59	64	70	78	91	97	100				17	33	21	9					5
RJ 13	0.1-0.7	30519	EW Granite	GW-GC				8	17	27	30	32	36	47	75	93	97	100			2	NON -	PLASTIC						
RJ 13	0.7-1.7	30520	EW Granite	SC	8	11	16	18	27	39	43	37	52	65	79	97	100				5	19	3	4					5
RJ 14	0.1-0.9	30521	Lateritic Gravel	GC				14	20	26	29	32	39	53	84	99	100				6	33	18	7					
RJ 15	0.1-0.5	30522	Lateritic Gravel	GW				4	8	13	15	17	21	30	47	54	56	86	100		2	22	11	6			2.19	6.5	
RJ 16	1.6-3.3	30523	EW Mudstone	CH	19	34	65	79	85	88	89	90	92	96	99	100					27	56	35	12					6
RJ 17	0.5-2.3	30524	Lateritic Clay	CH				58	70	80	83	86	91	96	99	100					26	58	39	14					
RJ 19	0.1-1.1	30525	Laterite	SC	25	34	44	47	57	64	66	68	73	83	94	98	100				19	54	31	13					5
RJ 19	1.1-3.3	30526	Lateritic Clay	CH				82	91	97	98	98	99	99	100						32	65	39	14					
RJ 20	0.2-0.5	30527	Laterite	SC				47	58	65	67	68	72	80	91	97	100				16	38	18	8					
RJ 20	0.5-3.2	30528	Lateritic Clay	CH				79	87	93	95	96	98	99	100						26	65	42	12	1.62	25.0			
RJ 22	1.6-3.9	30529	Lateritic Clay	CH				74	82	87	88	90	92	95	97	99	100				23	52	34	10					
RJ 23	0.2-0.6	30530	Lateritic Clay	CL				53	65	74	76	79	83	90	98	100					14	39	25	11					
RJ 23	2.6-3.6	30531	Lateritic Clay	CH				84	85	91	92	94	96	98	99	100					38	60	40	11					
RJ 25	0.2-1.9	30532	Lateritic Gravel	GC				24	27	30	31	32	35	42	72	95	100				18	65	43	15					
RJ 26	0.2-0.9	30534	Laterite	SC				34	41	48	50	52	57	62	86	98	100				11	35	20	8					
RJ 27	0.4-2.0	30537	EW Granite	SC				26	33	42	47	54	66	84	98	99	100				11	43	27	10			2.00	10.0	
RJ 28	0.1-0.5	30538	Lateritic Clay	SL	30	38	54	57	70	85	89	92	95	98	99	100					21	37	24	11					5
RJ 28	0.5-1.1	30539	Laterite	SC				49	58	68	71	74	79	86	95	99					20	49	34	14					

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT

SUMMARY OF SOIL TEST RESULTS

Meehan Burgess & Yeates 2306 Figure 6.1

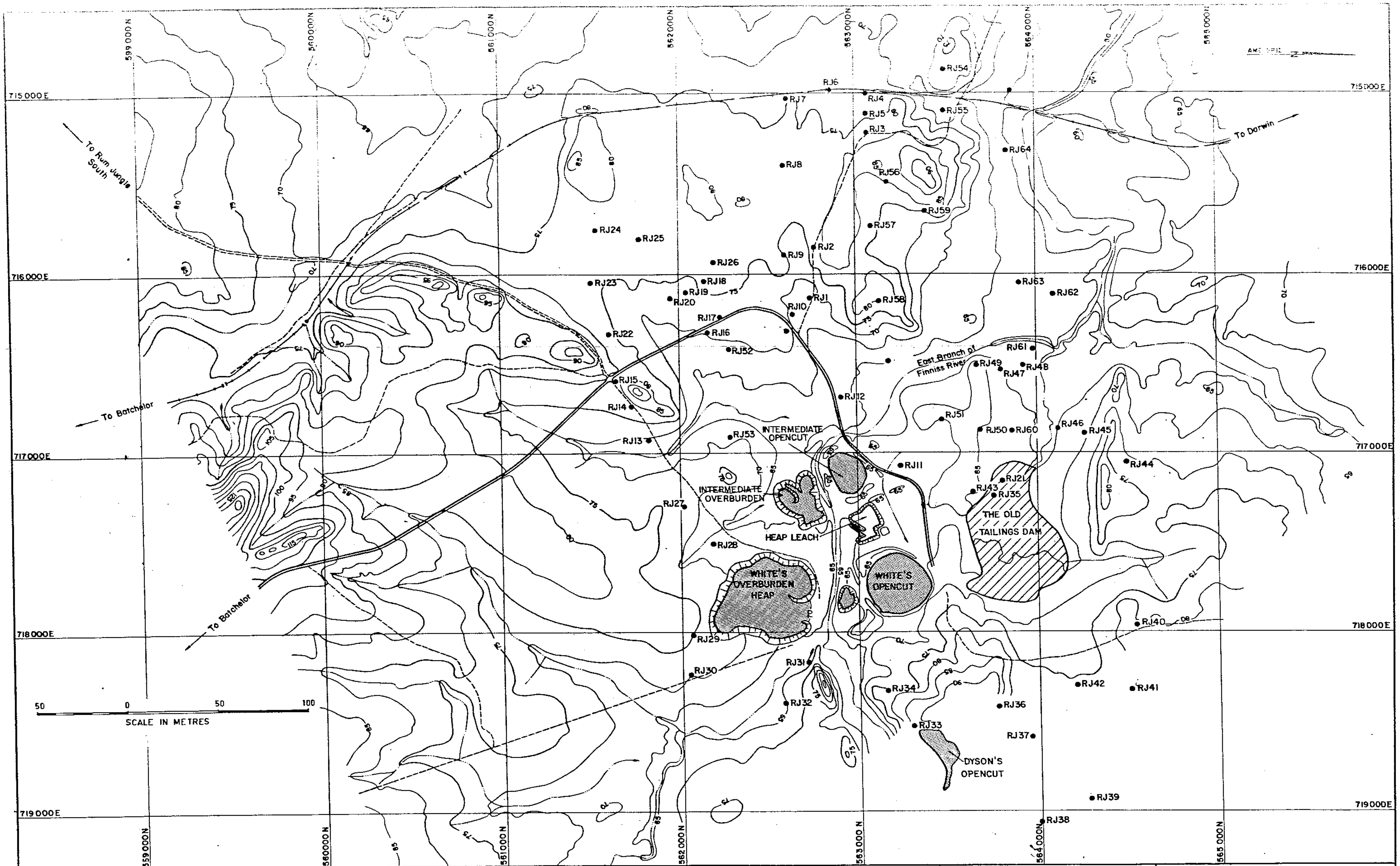
Pit No	Depth (m)	Sample No.	Geological Profile	USCS Symbol	Particle Size Distribution % of Total Dry Weight Passing B S Metric Sieve. Microns 2	10	50	75	150	300	425	600	Millimetres 1·18	2·36	4·75	9·5	19·0	37·5	63·0	As Received δ d t/m³	N.M.C %	Atterberg Limits WL	IP	Linear Shrink %	Compaction Stand. MDD t/m³	Stand. OMC %	Modif. MDD t/m³	Modif. OMC %	Emerson Class Number
RJ 28	1.1-2.0	30540	Lateritic Clay	CH				82	87	91	92	93	95	96	97	98	100				33	78	60	17					
RJ 28	2.0-3.7	30541	EW Mudstone	SC				36	49	67	78	88	97	100							40	43	20	8					
RJ 29	0.1-0.5	30542	Laterite	SW SC				11	17	30	37	44	51	61	81	97	100				4	21	10	5			2.16	6.5	
RJ 30	0.2-0.6	30543	Laterite	SC				29	39	51	55	59	65	69	87	99	100				8	38	27	10			2.12	8.5	
RJ 31	0.3-1.5	30544	EW Granite	SC				25	33	43	48	58	75	93	98	100					13	37	22	9					
RJ 36	0.6-1.5	30547	Laterite	SC	26	38	49	51	59	71	74	79	85	93	100						18	41	19	9					5
RJ 37	0.1-0.7	30548	Laterite	SC				19	33	51	59	68	80	90	97	99	100				15	46	30	12					
RJ 37	0.7-2.0	30549	Lateritic Gravel	GC				47	54	60	62	63	66	72	90	100					18	48	31	13					
RJ 38	0.1-0.5	30550	Laterite	SC				34	45	55	58	63	70	78	86	99	100				12	36	23	7					
RJ 38	0.5-0.8	30551	Laterite	SC				17	27	39	44	50	57	63	79	96	100				13	48	36	7					
RJ 38	0.8-1.5	30552	Lateritic Gravel	GC				30	39	48	50	53	57	60	79	99	100				20	55	30	12					
RJ 39	0.5-1.3	30553	Lateritic Gravel	GC				8	12	17	20	24	32	42	69	91	99	100			12	47	29	12					
RJ 39	0.2-0.5	30554	Lateritic Gravel	GC				13	21	32	37	40	44	48	62	86	99	100			7	33	20	6					
RJ 40	0.3-1.2	30555	EW Granite	SC				22	28	33	35	39	50	68	88	99	100				5	32	16	7					
RJ 41	0.6-1.1	30556	Lateritic Gravel	GC				14	17	20	21	22	23	29	43	62	79	83	100		7	42	24	11					
RJ 41	0.2-0.6	30557	Laterite	SC				36	52	70	74	78	83	90	96	100					8	31	21	7					
RJ 42	0.2-0.8	30558	Lateritic Clay	CH				50	56	63	65	67	71	81	94	99	100				16	63	46	19					
RJ 42	0.8-1.2	30559	Lateritic Gravel	GC				19	23	27	28	30	33	41	71	92	98	100			14	72	55	19					
RJ 43	0.4-1.7	30560	Lateritic Gravel	GC				13	20	32	36	39	45	54	70	85	94	100			4	29	18	7			2.20	6.5	
RJ 43	1.7-3.6	30561	Lateritic Gravel	GC				16	26	41	44	46	49	52	59	75	96	100			8	25	12	5					
RJ 44	0.2-0.8	30562	Laterite	SC	6	12	22	29	41	66	76	84	88	96	100						3	NON - PLASTIC							5
RJ 46	0.2-1.8	30563	Lateritic Gravel	GC				46	51	57	58	60	61	63	90	100					18	54	45	17					
RJ 46	1.8-3.8	30564	Lateritic Clay	GH				75	84	90	91	92	94	95	97	98	100				47	85	55	19	1.25	38.5			
RJ 48	0.0-0.3	30566	Alluvium	GC				41	51	57	58	58	59	59	79	100					8	21	8	3	1.90	11.5			
RJ 50	0.1-0.5	30567	Colluvium	CG				8	13	18	20	20	21	23	30	43	64	64	89		3	23	13	5					
RJ 50	0.5-1.8	30568	Lateritic Gravel	GC				14	20	27	29	32	37	44	71	91	97	100			11	41	28	11					
RJ 51	0.4-0.8	30569	Lateritic Gravel	GC				13	17	21	23	24	25	31	55	84	93	100			13	33	19	10					
RJ 52	0.2-0.7	30571	Laterite	SC				45	48	50	51	53	63	80	99	99	100				16	26	11	7					
RJ 56	0.0-1.4	30574	Lateritic Gravel	GC				13	15	18	19	20	21	25	40	65	87	96	100		8	34	16	8					
RJ 57	0.1-1.1	30576	Laterite	SC	27	35	41	43	53	68	73	79	87	93	100						10	30	17	9					
RJ 60	0.1-0.6	30579	Alluvium	SC	20	30	40	44	53	68	78	83	88	92	100						11	27	13	8					
RJ 60	0.6-2.0	30580	Lateritic Gravel	GC				17	20	24	26	28	30	36	59	96	100				14	37	25	11					
RJ 61	0.1-1.0	30581	Alluvium	SC				16	32	68	82	94	99	100							4	NON _ PLASTIC							
RJ 62	0.2-1.8	30582	Lateritic Clay	CL				55	66	79	83	86	90	94	99	100					15	41	27	11	1.83	15.0			
Combined		30585	Laterite	SC	10	16	21	22						84															

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT

SUMMARY OF SOIL TEST RESULTS

Meehan Burgess & Yeates 2306 Figure 6.2



No.	DATE	DESCRIPTION	APPD.
		REVISIONS	

NOTES:

- ● RJ Test Pit.
- Sealed Road
- Unsealed Road
- Dirt Track
- River, stream, flowing during wet
- Mill Tailings

LEVEL DATUM	AHD		
REF. B.M.			
AZIMUTH	AMG		
DRAWN:	RPD	DATE:	
TRACED:	M.W.	DATE:	MAY 1982
CHECKED:	G.B.A.	DATE:	MAY 1982

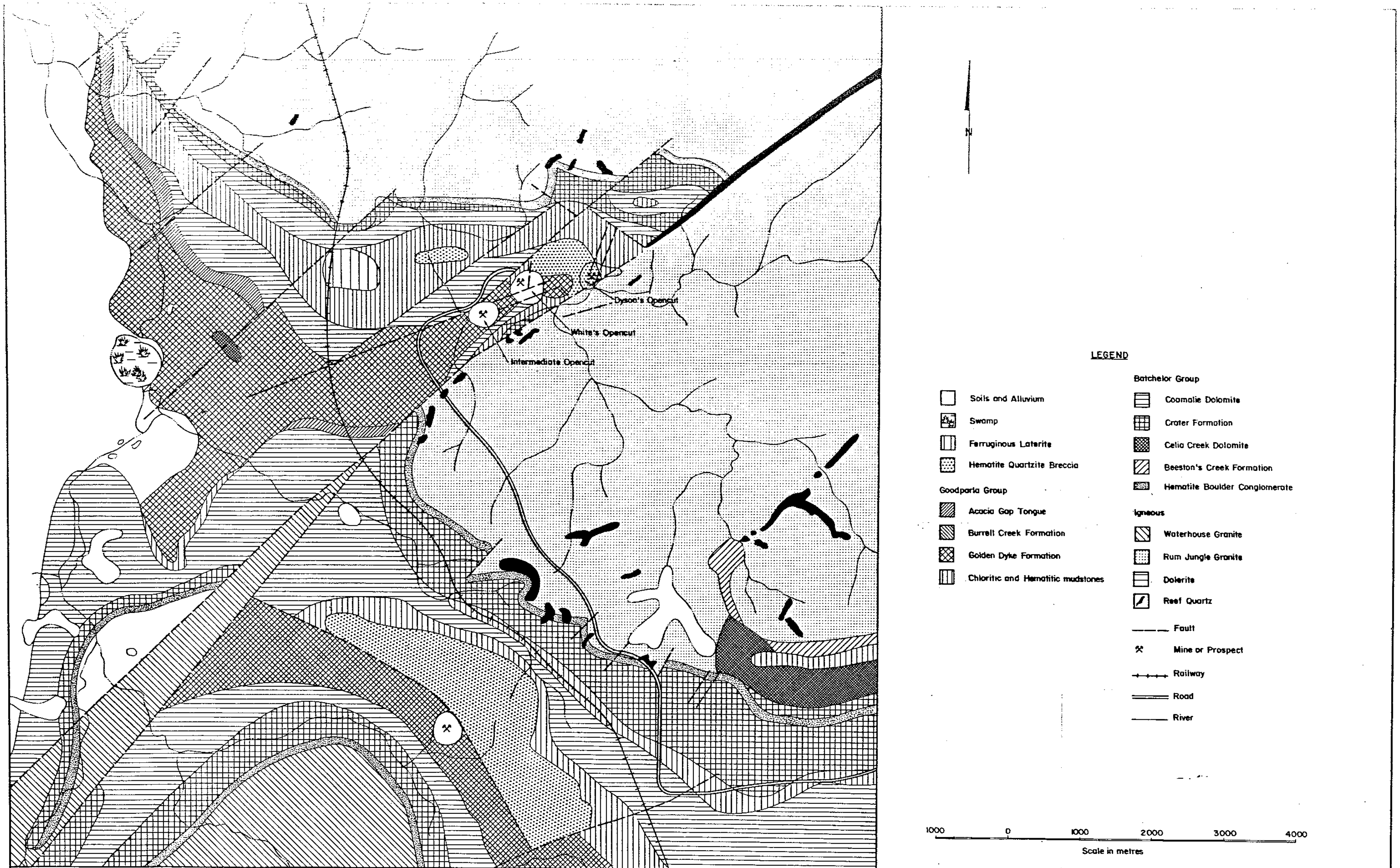
Meehan Burgess & Yeates
Consulting Engineers & Geologists

PASSED:
DATE:

RUM JUNGLE REHABILITATION PROJECT

LOCATION OF EXPLORATION

DRG. No.: 2306-003 FIGURE S1-1



No.	DATE	DESCRIPTION	APPD.

REVISIONS

NOTES:

LEVEL DATUM
REF. B.M.
AZIMUTH
DRAWN: DATE:
TRACED: MW DATE: MAY '82
CHECKED: G.B.A. DATE: MAY '82

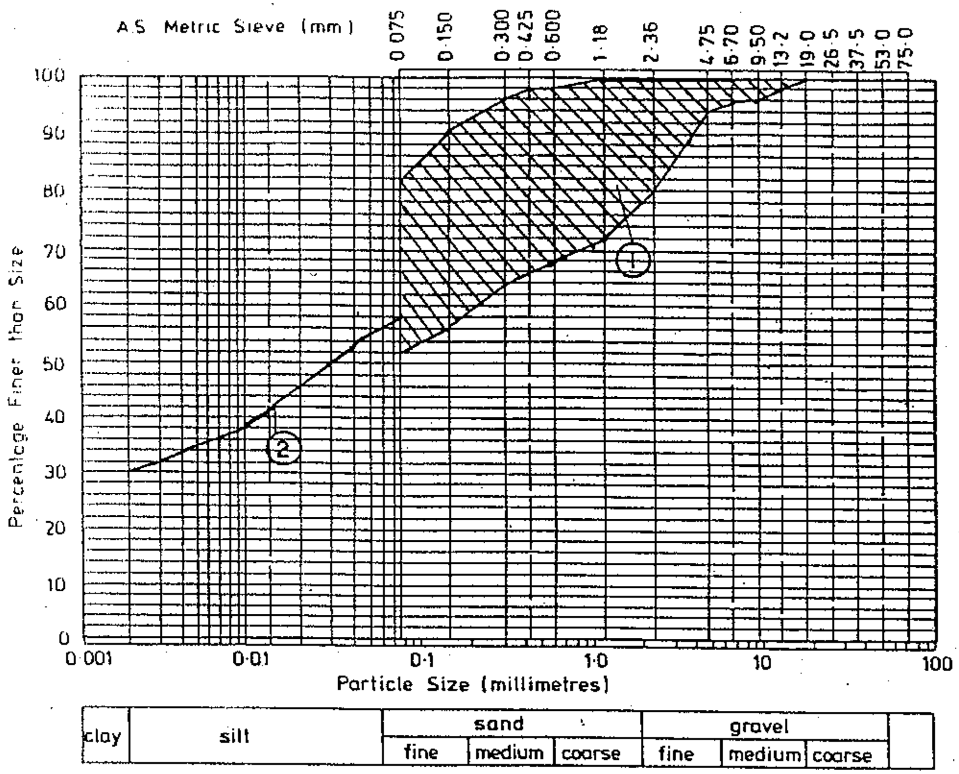
Meehan Burgess & Yeates
Consulting Engineers & Geologists

PASSED:
DATE:

RUM JUNGLE REHABILITATION PROJECT

GEOLOGICAL MAP

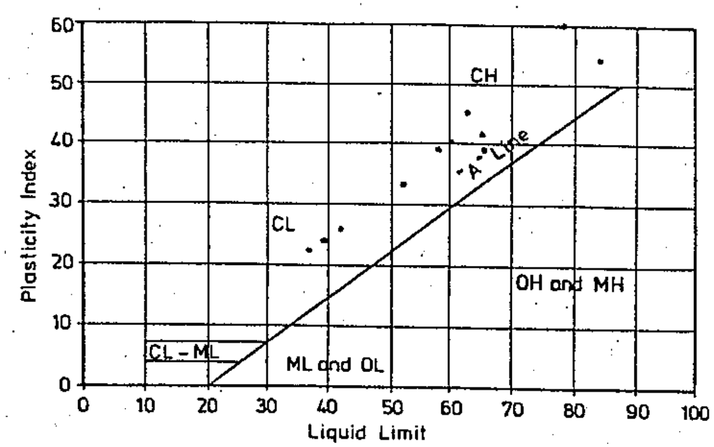
DRG. NO. 2306-004 FIGURE S 2·1



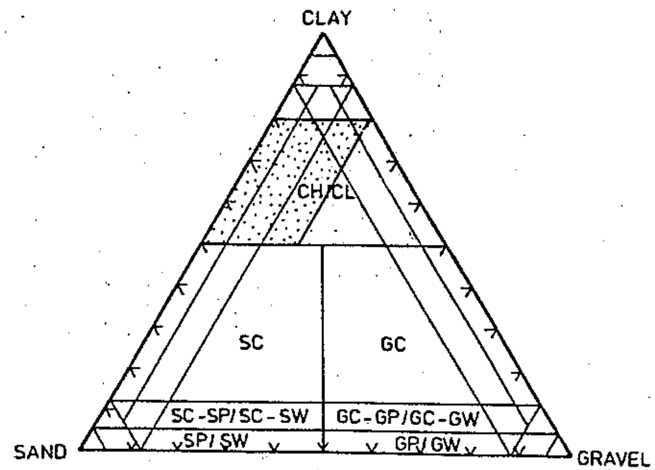
PARTICLE SIZE DISTRIBUTION

i) Envelope of particle size distributions for all lateritic clays samples

ii) Hydrometer analysis of sample No. 30538



PLOT OF PLASTICITY / LIQUID LIMIT



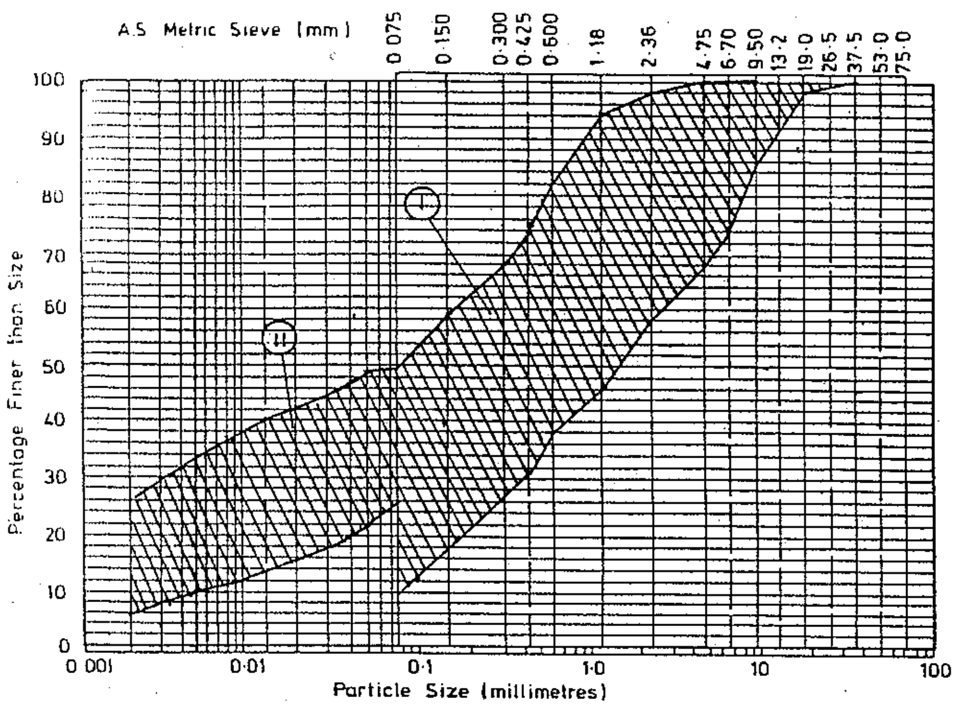
SOIL CLASSIFICATION CHART

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT

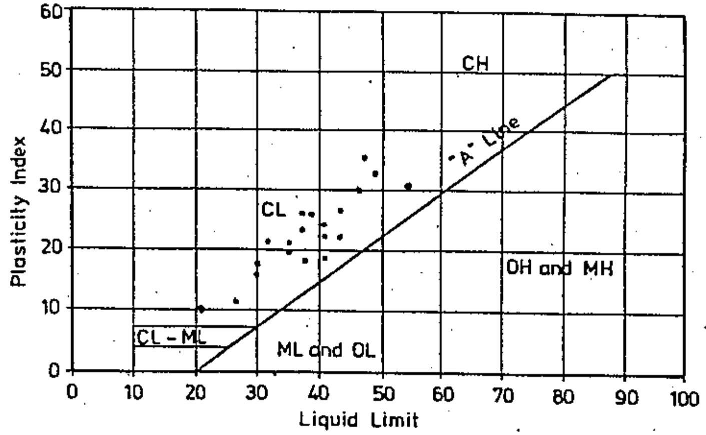
SUMMARY OF MATERIAL PROPERTIES LATERITIC CLAY

Meehan Burgess & Yeates	2306	Figure S 3.1

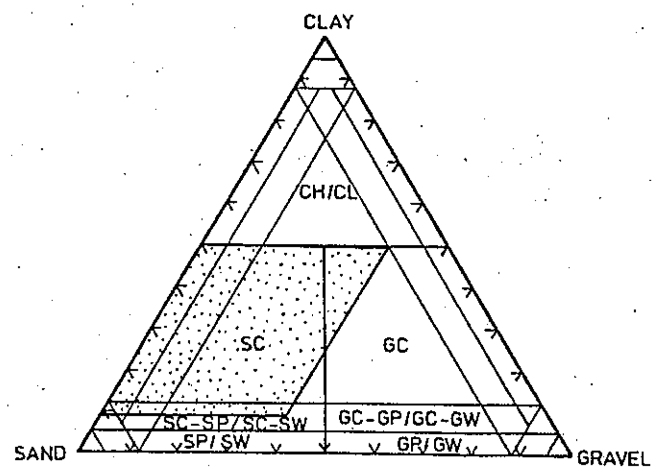


PARTICLE SIZE DISTRIBUTION

i) Envelope of particle size distributions for all laterite samples
ii) Envelope of hydrometer analysis for sample Nos. 30525
30547
30562
30576
30585



PLOT OF PLASTICITY / LIQUID LIMIT

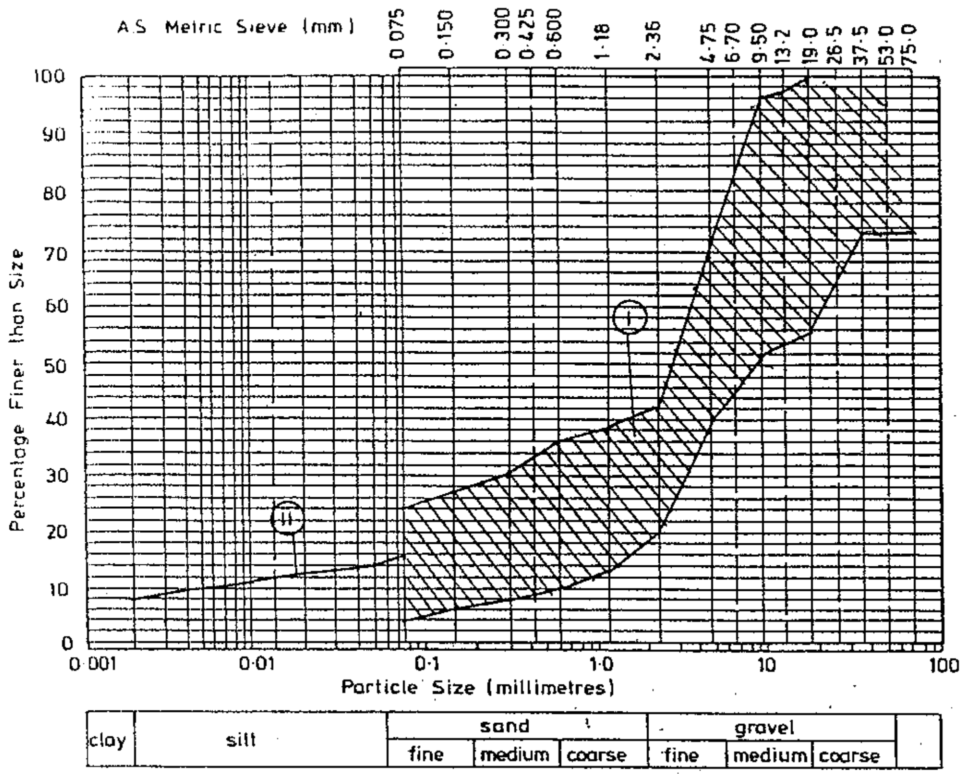


SOIL CLASSIFICATION CHART

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT
SUMMARY OF MATERIAL PROPERTIES - LATERITE

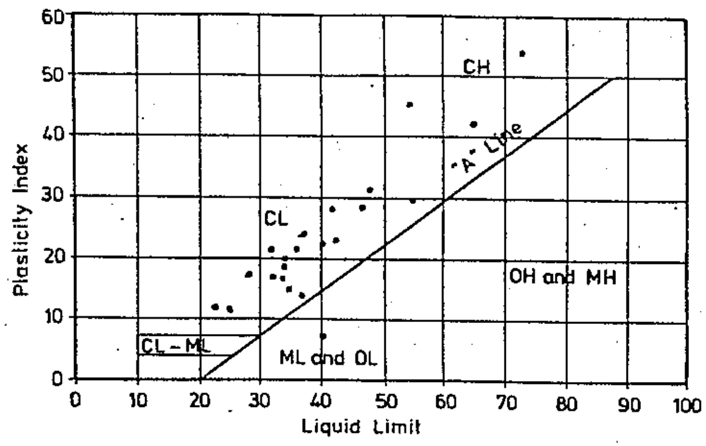
Meehan Burgess & Yeates | 2306 | Figure 5.?



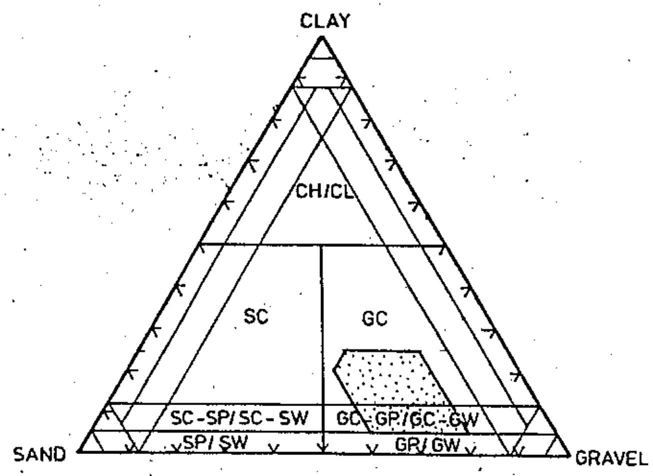
PARTICLE SIZE DISTRIBUTION

i) Envelope of particle size distribution of all lateritic Gravel samples

ii) Hydrometer analysis for sample No. 30502



PLOT OF PLASTICITY / LIQUID LIMIT



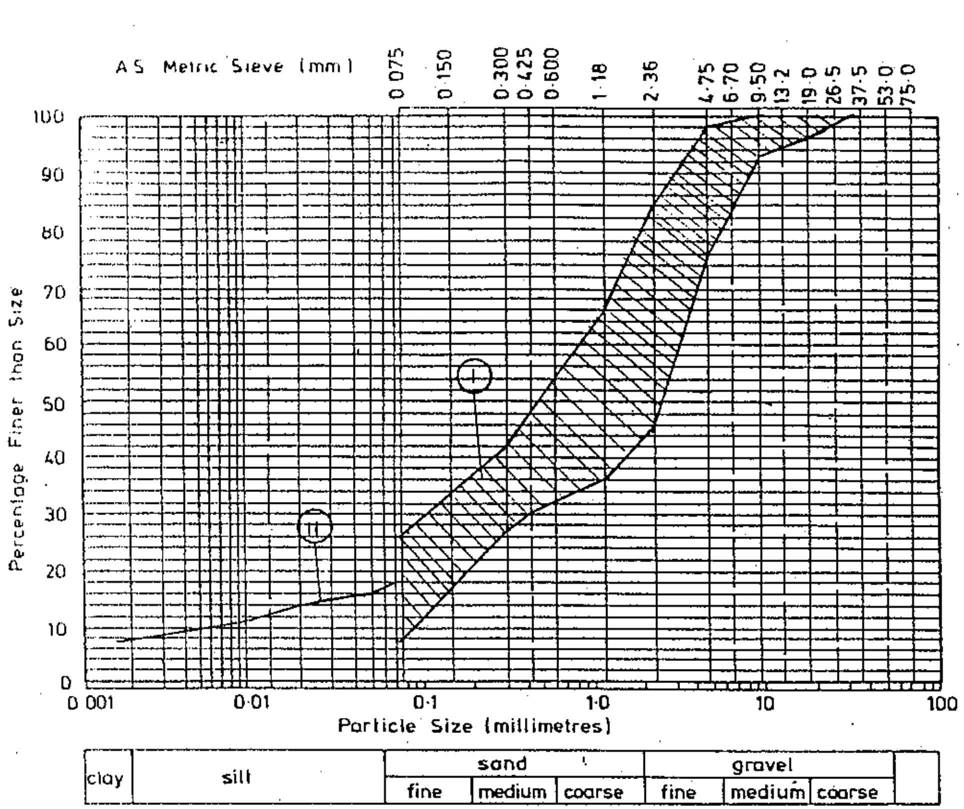
SOIL CLASSIFICATION CHART

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT

SUMMARY OF MATERIAL PROPERTIES - LATERITIC GRAVEL

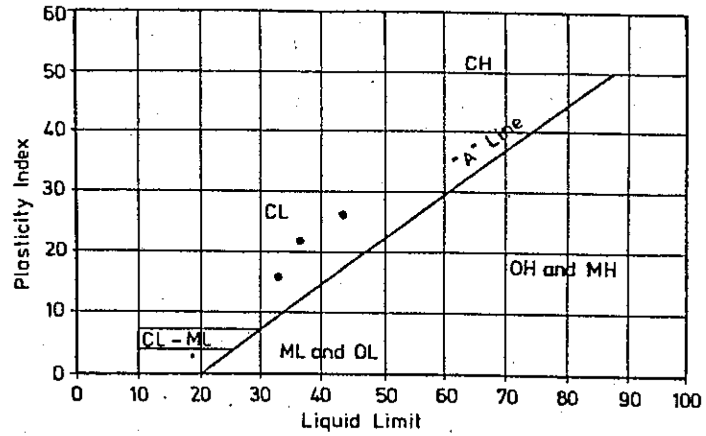
Meehan Burgess & Yeates | 2306 | Figure S 3.3



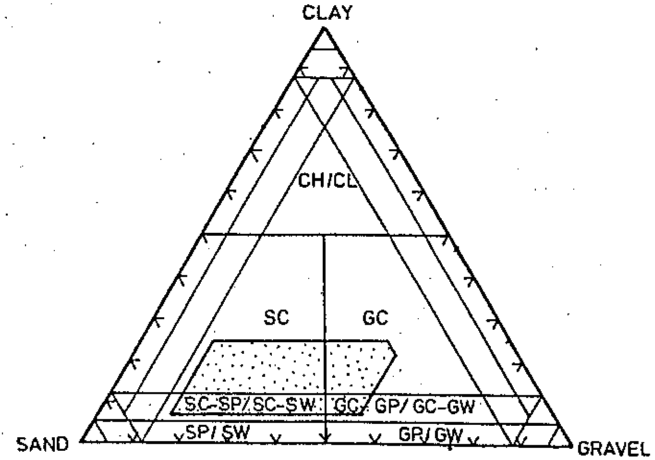
PARTICLE SIZE DISTRIBUTION

i) Envelope of particle size distribution for all EW Granite samples

ii) Hydrometer analysis od sample No. 30520



PLOT OF PLASTICITY / LIQUID LIMIT



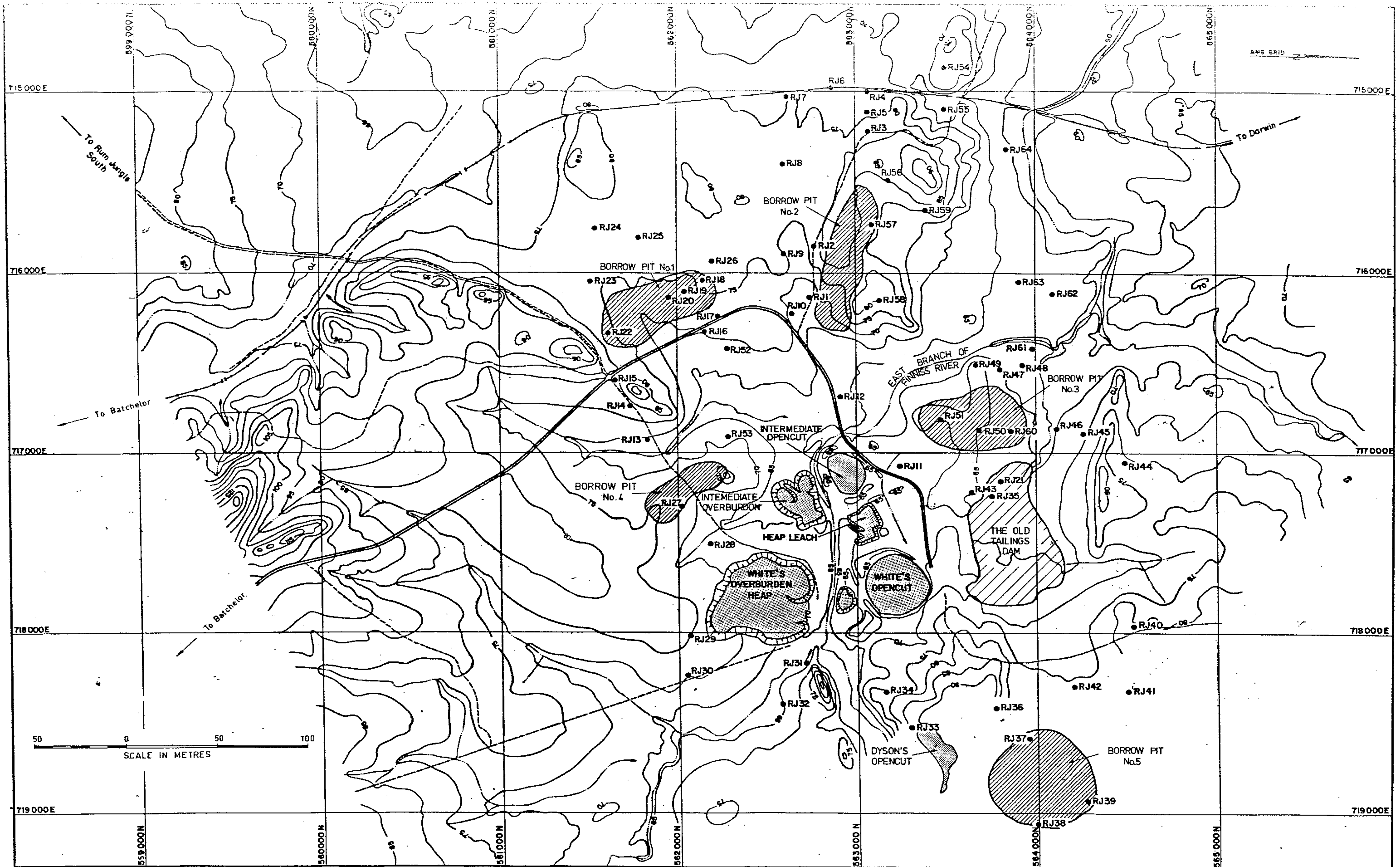
SOIL CLASSIFICATION CHART

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT

SUMMARY OF MATERIAL PROPERTIES - EXTREMELY WEATHERED GRANITE

Meehan Burgess & Yeates	2306	Figure S 3.4



NOTES:

- ● RJ Test Pit.
- Sealed Road
- Unsealed Road
- Dirt Track
- River, stream flowing during wet
- Mill Tailings

No.	DATE	DESCRIPTION	APPD.
		REVISIONS	

LEVEL DATUM AHD
REF. B.M.
AZIMUTH AMG
DRAWN: RPD DATE:
TRACED: M.W. DATE: MAY 1982
CHECKED: G.B.A. DATE: MAY 1982

Meehan Burgess & Yeates
Consulting Engineers & Geologists

PASSED:
DATE:

RUM JUNGLE REHABILITATION PROJECT

LOCATION OF BORROW AREAS

DRG. No. - 2306-005

FIGURE S4-1

Excavation Log

Excavation no	RJ 28
Job no	2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

RL:

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		CL SANDY CLAY some GRAVEL brown,. Some roots.	
	Lateritic Clay		2.9		CH SANDY CLAY some GRAVEL High plasticity,fine to medium grained sand red,moist,MC < PL Some roots.	Very Stiff
	Lateritic Clay		3.4		CH CLAY some SAND some GRAVEL High plasticity,fine to medium grained sand fine to medium grained gravel,red and yellow/brown,moist,MC < PL	Stiff
					Pit terminated at 3.4m - limit of reach,easy digging	

Logged by: R.P.B.D. Date: 23.4.82

Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ 33

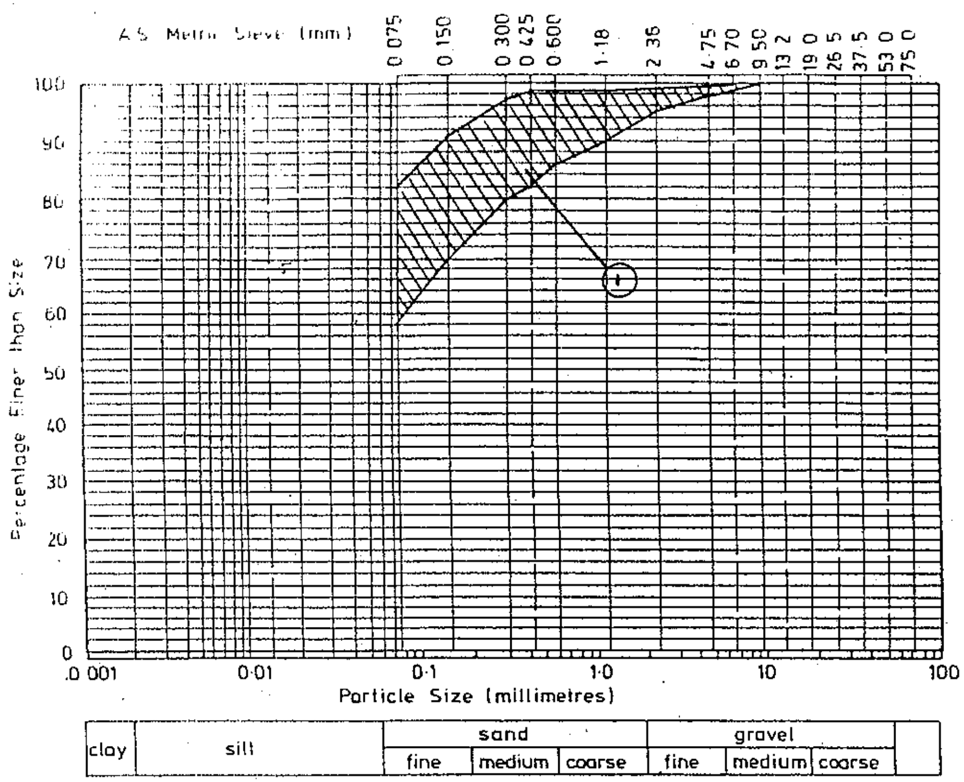
Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No.	2306
Project	RUM JUNGLE REHABILITATION PROJECT
R L	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		GW GC SANDY GRAVEL some CLAY light brown, Some roots.	
30519	EW Granite		.7		GW GC SANDY GRAVEL some CLAY Fine to medium grained gravel,fine to medium grained sand,fines of low plasticity,yellow brown,discontinuous sand drains,dry Some roots; angular quartz fragments.	Loose
30520	EW Granite		1.7		SC GRAVELLY SAND with considerable CLAY Fine to coarse grained sand,fine grained gravel,fines of low plasticity,red white brown and yellow brown,discontinuous sand drains,moist Some roots; angular quartz fragments.	Medium Dense
•	EW Granite		2.0		SC GRAVELLY SAND with considerable CLAY Fine to medium grained sand,fine grained gravel,fines of low plasticity,grey red and brown,moist Angular quartz fragments; hard digging.	Very Dense

Pit terminated at 2m - refusal

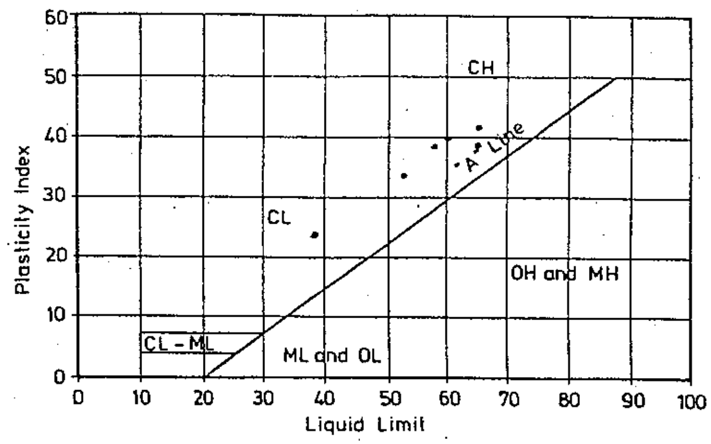
Logged by	R.P.B.D.	Date	23.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

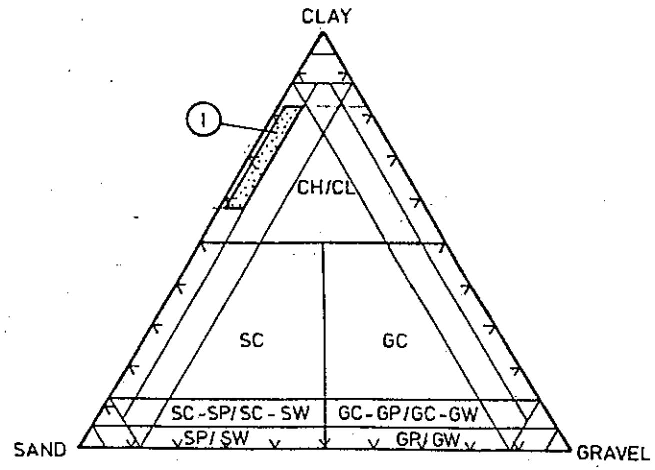


PARTICLE SIZE DISTRIBUTION

i) Lateritic Clay
Natural Moisture Content Range 14% to 38%

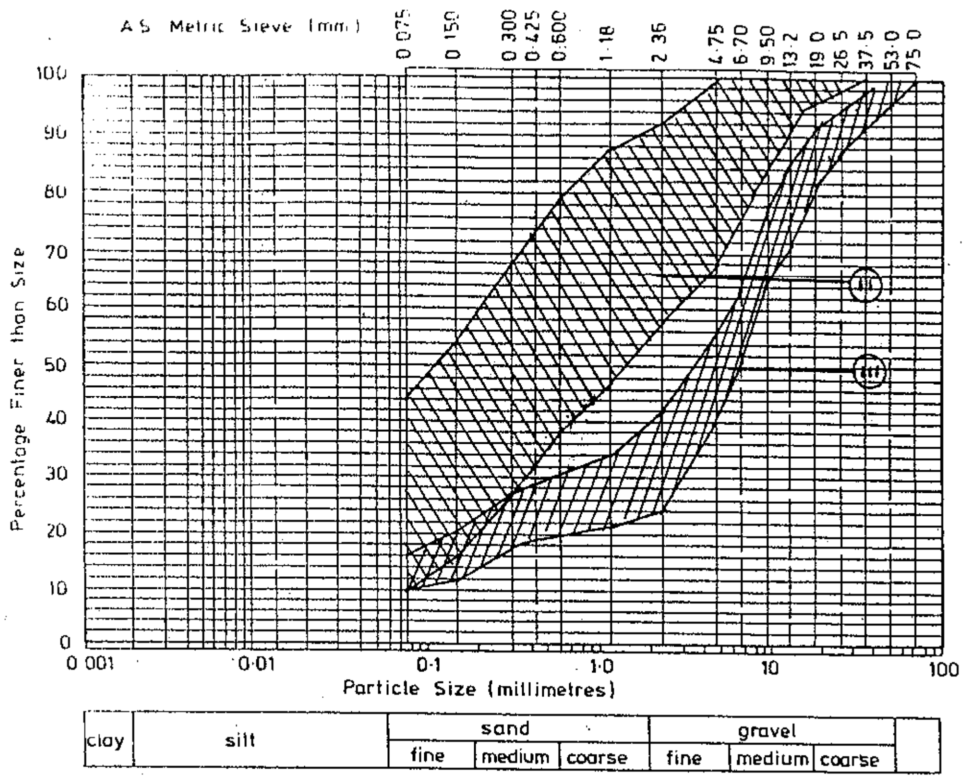


PLOT OF PLASTICITY / LIQUID LIMIT



SOIL CLASSIFICATION CHART

Revisions	Date	RUM JUNGLE REHABILITATION PROJECT MATERIAL PROPERTIES FOR BORROW AREA 1.
		Meehan Burgess & Yeates
		2306
		Figure S 4.2



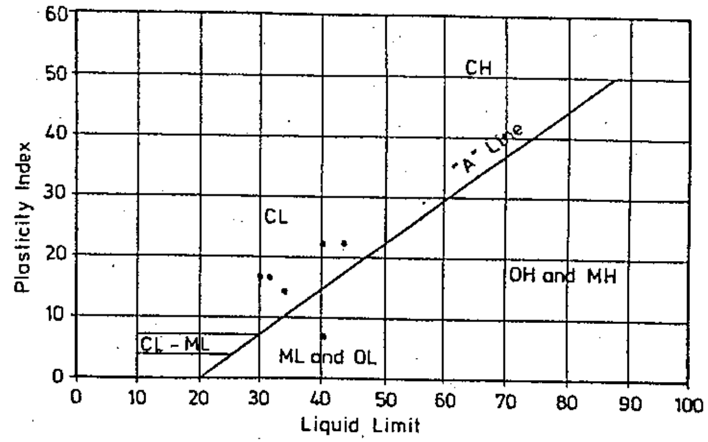
PARTICLE SIZE DISTRIBUTION

ii) Laterite

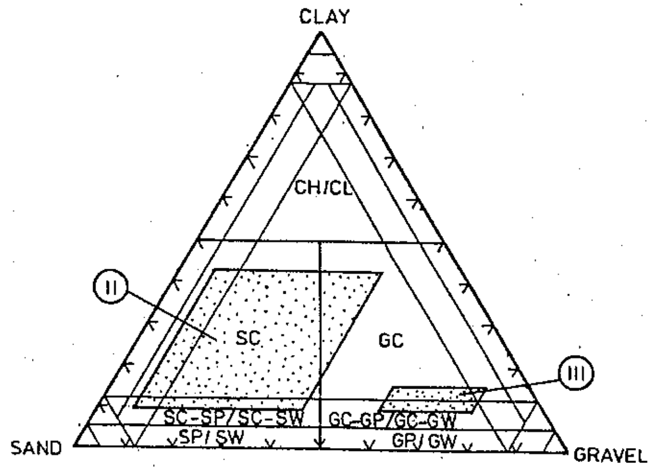
Natural Moisture Content Range - 9% to 20%

iii) Lateritic Gravel

Natural Moisture Content Range - 8% to 12%



PLOT OF PLASTICITY / LIQUID LIMIT



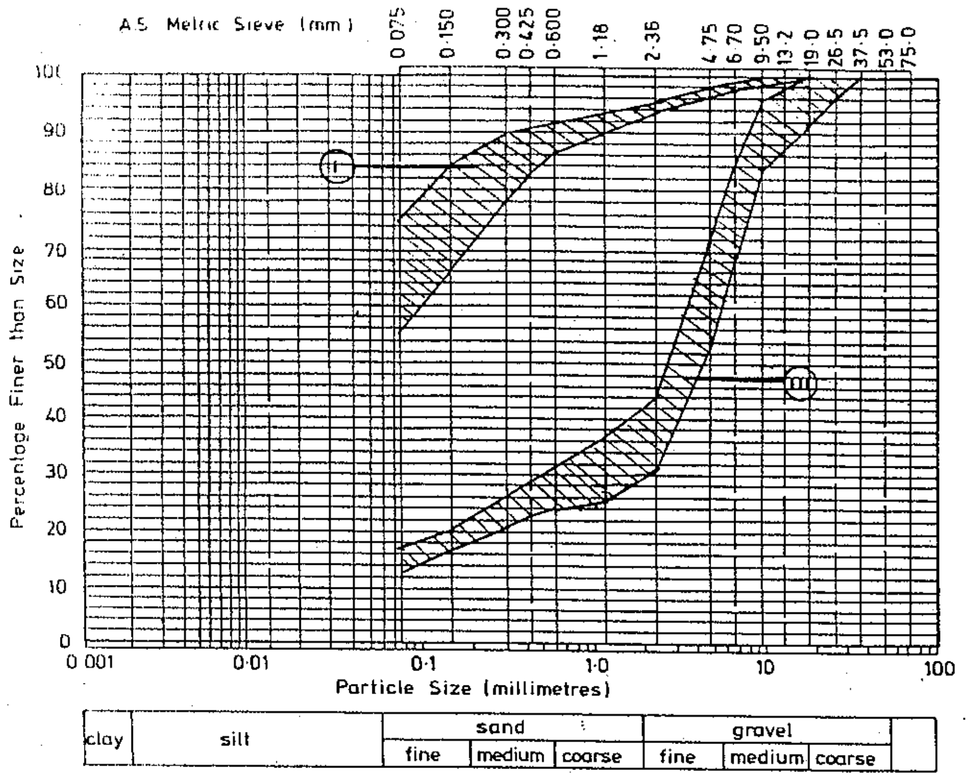
SOIL CLASSIFICATION CHART

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT

MATERIAL PROPERTIES FOR BORROW AREA 2.

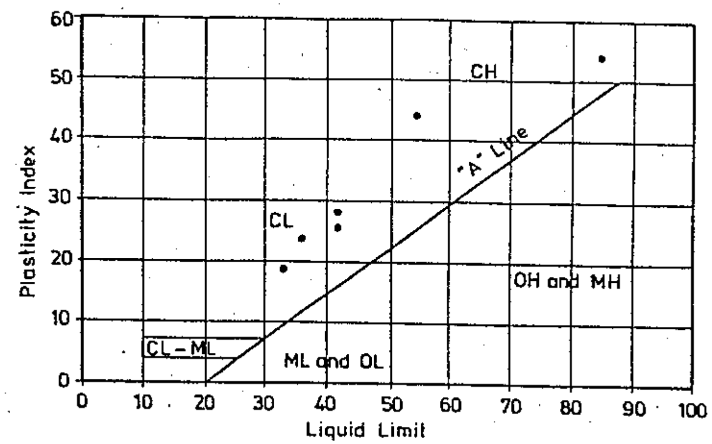
Meehan Burgess & Yeates | 2306 | Figure 5 4.3



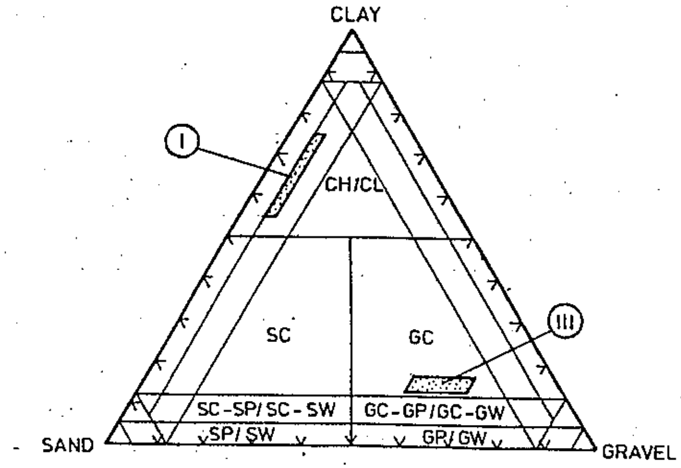
PARTICLE SIZE DISTRIBUTION

i) Lateritic Clay
Natural Moisture Content Range - 15% to 47%

iii) Lateritic Gravel
Natural Moisture Content Range - 11% to 18%



PLOT OF PLASTICITY / LIQUID LIMIT

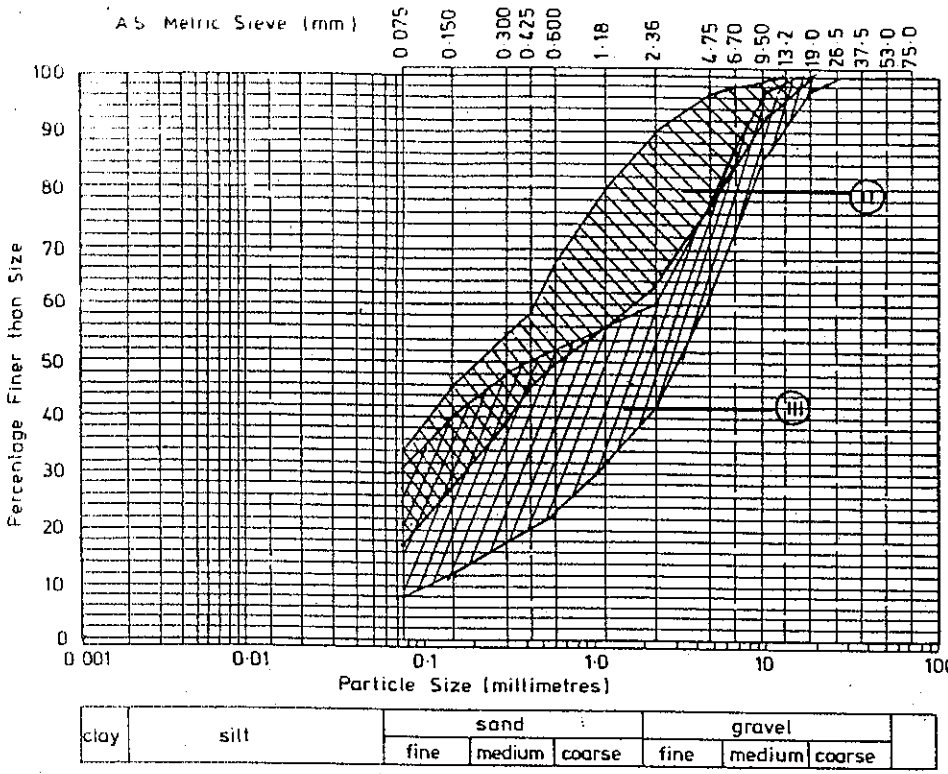


SOIL CLASSIFICATION CHART

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT
MATERIAL PROPERTIES FOR BORROW AREA 3.

Meehan Burgess & Yeates | 2306 | Figure S 4.4



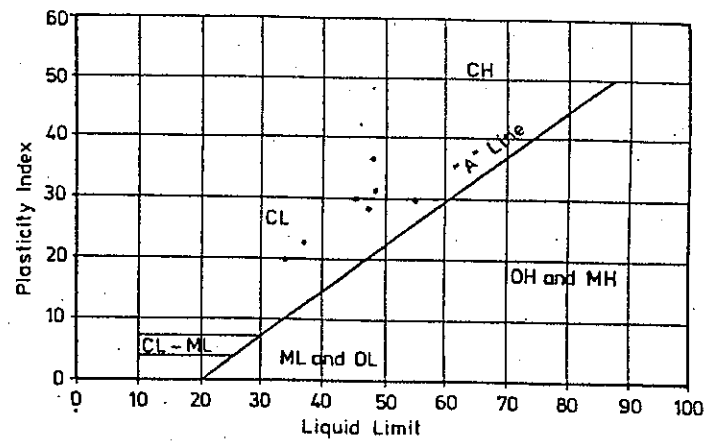
PARTICLE SIZE DISTRIBUTION

ii) Laterite

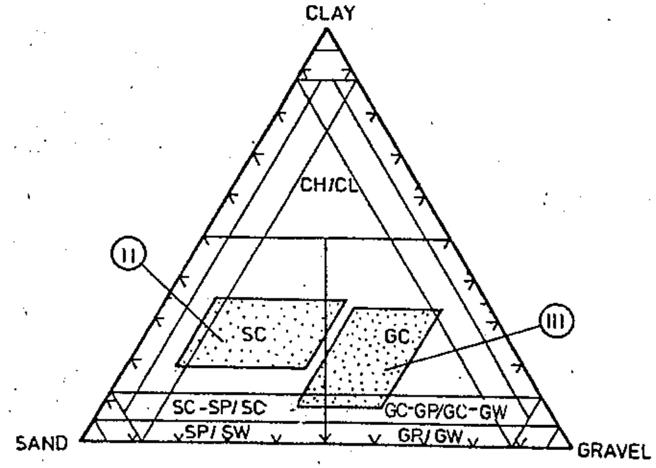
Natural Moisture Content Range - 12% to 15%

iii) Lateritic Gravel

Natural Moisture Content Range - 7% to 20%



PLOT OF PLASTICITY / LIQUID LIMIT



SOIL CLASSIFICATION CHART

Revisions	Date

RUM JUNGLE REHABILITATION PROJECT
MATERIAL PROPERTIES FOR BORROW AREA 4.

Meehan Burgess & Yeates | 2306 | Figure S 4.5

APPENDIX A

COMPILATION OF EXCAVATION LOGS

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 1

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job No: 2306

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with considerable GRAVEL Fines of low plasticity,brown,dry	
30503	Laterite		1.0		SC CLAYEY SAND with considerable GRAVEL Fine to medium grained sand,fine grained gravel,fines of low plasticity,red,dry	Medium Dense
30502	Lateritic Gravel		2.1		GC SANDY GRAVEL with considerable CLAY Fine to coarse grained gravel,fine to coarse grained sand,fines of medium plasticity,red moist	Medium Dense
30501	Laterite		3.0		SP SC GRAVELLY SAND some CLAY Fine to coarse grained sand,fine to medium grained gravel,fines of medium plasticity red,moist	Dense
	EW Greywacke		3.1		GP GC SANDY GRAVEL some CLAY grey white yellow, easy digging	Very Dense

Pit terminated at 3.1m - pit refusal

Logged by: G.B.A. Date: 20.4.82

Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no: RJ 2

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job no: 2306

Project: RUM JUNGLE REHABILITATION PROJECT

R.L.

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		GW GC SANDY GRAVEL some CLAY brown,	
30504	Lateritic Gravel				GW GC SANDY GRAVEL some CLAY Fine to medium grained gravel, fines of medium plasticity, red, porous structure, moist	Loose
30505	EW Rock		2.3		GW SANDY GRAVEL with a trace of CLAY Medium to coarse grained gravel, medium to coarse grained sand, red brown/yellow brown mottled, moist	Very Dense
			3.5		Pit terminated at 3.5m - limit of reach	

Logged by: G.B.A. Date: 21.4.82

Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ 3

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job No. 2306

Project: RUM JUNGLE REHABILITATION PROJECT

R.L.

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		GC CLAYEY GRAVEL with some SAND brown,	
30506	Laterite		1.6		GC CLAYEY GRAVEL with considerable SAND Fine to coarse grained gravel, fines of low plasticity, red, moist	Loose
	EW Rock		2.8		SW SC GRAVELLY SAND some CLAY Medium grained sand, fine to medium grained gravel, fines of low plasticity, red brown/yellow brown mottled, moist Hard digging.	Very Dense
					Pit terminated at 2.8m - refusal	

Logged by: G.R.A. Date: 21.4.82 Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job no 2306
Project: RUM JUNGLE REHABILITATION PROJECT	RL

RJ -

Equipment type: Backhoe
Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY SAND with considerable GRAVEL brown,	
30508	Laterite				SC CLAYEY SAND with some GRAVEL Fine to coarse grained sand, fine grained gravel, fines of medium plasticity, red, moist Some roots.	Medium Dense
30507	Lateritic Gravel		2.8 – 3.2		GC SANDY GRAVEL with considerable CLAY Fine grained gravel, fine to coarse grained sand, fines of medium plasticity, red brown/yellow brown mottled, moist	Dense
					Pit terminated at 3.2m - limit of reach, easy digging	

Logged by G.B.A.	Date 21.4.82	Checked by: J.J.A.	Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Location no: RJ 5

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil				SC GRAVELLY SAND with considerable CLAY brown, Some roots.	
30510	Laterite		.1		SC GRAVELLY SAND with considerable CLAY Fine to coarse grained sand,fine to medium grained gravel,fines of medium plasticity red,moist Some roots.	Medium Dense
	Lateritic Gravel		.8		GC CLAYEY GRAVEL with some SAND Fine to medium grained gravel,fines of low plasticity,red,porous structure,moist	Dense
30509	Lateritic Gravel		1.7		GW SANDY GRAVEL with a trace of CLAY Fine to medium grained gravel,coarse grained sand,red,porous structure,moist	Very Dense
			2.1		Pit terminated at 2.1m - hard digging at refusal	

Logged by	G.B.A.	Date:	21.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 6

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD

Job No: 2306

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil				SC CLAYEY SAND with some GRAVEL brown, Some roots.	
30511	Laterite		.4		SC CLAYEY SAND with a trace of GRAVEL Fine to medium grained sand, fines of medium plasticity, red, moist Some roots.	Dense
	Lateritic Gravel		1.7		GC SANDY GRAVEL with considerable CLAY Medium grained gravel, fines of medium plasticity, red, moist Some roots.	Dense
30512	EW Rock		2.9		SC GRAVELLY SAND with considerable CLAY Fine to coarse grained sand, fine grained gravel, fines of medium plasticity, red brown/yellow brown mottled, moist	Very Dense
			3.5		Pit terminated at 3.5m - limit of reach, easy digging	

Logged by: R.P.B.D. Date: 22.4.82 Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation: RJ 7

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job no: 3306

Project: RUM JUNGLE REHABILITATION PROJECT

R.L.

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY SAND with some GRAVEL brown, Some roots.	
30513	Laterite		.8		SC CLAYEY SAND with some GRAVEL Fine to coarse grained sand, fine grained gravel, fines of medium plasticity, red, moist Some roots.	Medium Dense
30515	Lateritic Gravel		1.6		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, fine to medium grained sand, fines of low plasticity, red, moist Some roots.	Medium Dense
30514	EW Dolomite		3.2		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, coarse grained sand, fines of low plasticity, red brown/yellow brown mottled, infill clay on joints, moist variable density; very irregular fractures and easy digging.	Very Dense
					Pit terminated at 3.2m - refusal	

Logged by R.P.B.D.	Date 22.4.82	Checked by: J.J.A.	Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no	RJ 8
Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY SAND with some GRAVEL brown, Some roots.	
30516	Laterite				SC CLAYEY SAND with a trace of GRAVEL Fine to coarse grained sand, fines of medium plasticity, red, porous structure, moist Some roots.	Medium Dense
			4		Pit terminated at 4m - limit of reach, easy digging	

Logged by	R.P.B.D.	Date	22.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 9

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil				GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
	Lateritic Gravel		.4		GW GC SANDY GRAVEL some CLAY Fine to medium grained gravel, medium to coarse grained sand, fines of low plasticity red, porous structure, moist Some roots.	Loose
	EW Rock		1.0		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, coarse grained sand, fines of low plasticity, red brown/yellow brown mottled, moist Hard digging.	Very Dense
			3.0		Pit terminated at 3m - refusal	

Logged by	R.P.B.D.	Date:	22.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no.	RJ 10
Client:	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no.	2306
Project:	RUM JUNGLE REHABILITATION PROJECT
R.L.	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		SC GRAVELLY SAND with considerable CLAY brown, Some roots.	
	Colluvium		1.0		SC GRAVELLY SAND with considerable CLAY Fine to medium grained sand, medium grained gravel, fines of low plasticity, red, moist Some roots; maximum size 200 mm.	Medium Dense
30517	Laterite		1.7		SC GRAVELLY SAND with considerable CLAY Fine to coarse grained sand, fine to medium grained gravel, fines of medium plasticity red, moist	Medium Dense
	EW Siltstone/sandstone		3.2		SC CLAYEY SAND with some GRAVEL Fine to medium grained sand, fines of medium plasticity, red brown/yellow brown mottled porous structure, moist Angular quartz fragments; maximum size 100 mm and easy digging.	Very Dense
					Pit terminated at 3.2m - refusal	

Logged by	R.P.B.D.	Date	22.4.82	Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no. RJ 11

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with considerable GRAVEL dark brown, Some roots.	
30518	Alluvium		1.0		SC GRAVELLY SAND with considerable CLAY Fine grained sand, fine grained gravel, fines of low plasticity, dark brown, moist Some roots.	Medium Dense
	EW Rock	▼ 2.3	2.3		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, medium grained sand, fines of medium plasticity, red brown/yellow brown mottled, wet Water table at 2.3m depth.	Dense
			3.7			
					Pit terminated at 3.7m - limit of reach, easy digging	

Logged by R.P.B.D.	Date 22.4.82	Checked by: J.J.A.	Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ 12

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No.	2306
Project	RUM JUNGLE REHABILITATION PROJECT
R.L.	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with considerable GRAVEL brown, Some roots.	
	Laterite		.6		SW SC GRAVELLY SAND some CLAY Fine to medium grained sand, fine grained gravel, fines of low plasticity, red, dry Some roots.	Dense
	Lateritic Gravel		1.8		GC SANDY GRAVEL with considerable CLAY Coarse grained gravel, medium to coarse grained sand, fines of medium plasticity, red dry Maximum particle size 80mm; hard digging.	Dense
					Pit terminated at 1.8m - refusal	

Logged by: R.P.B.D. Date: 22.4.82 Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 14

Client:	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
30521	Lateritic Gravel		.9		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, fine to coarse grained sand, fines of low plasticity, red and yellow brown, discontinuous sand drains, dry Some roots; angular quartz fragments.	Medium Dense
	EW Granite		1.3		GW GC SANDY GRAVEL some CLAY Fine grained gravel, medium to coarse grained sand, fines of low plasticity, red white brown and yellow brown, dry Angular quartz fragments; hard digging.	Dense
					Pit terminated at 1.3m - refusal	

Logged by	R.P.B.D.	Date.	23.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

RJ 15

Job No. 2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

R.L.

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
30522	Lateritic Gravel				GW SANDY GRAVEL with a trace of CLAY Fine to coarse grained gravel, coarse grained sand, brown, porous structure, dry Some roots; angular quartz fragments; maximum gravel size 80mm.	Medium Dense
	Lateritic Gravel		.5		GW GC SANDY GRAVEL some CLAY Fine to medium grained gravel, medium grained sand, fines of medium plasticity, red and yellow brown, porous structure, moist Angular quartz fragments.	Loose
	EW Rock		1.5		SW SC GRAVELLY SAND some CLAY Fine to medium grained sand, fine grained gravel, fines of medium plasticity, red white and yellow brown, moist Angular quartz fragments; hard digging.	Dense
			2.0		Pit terminated at 2m - refusal	

Logged by: R.P.B.D. Date: 23.4.82

Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 16

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No	2306
Project:	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistancy Rel Density Hand Penetrometer
	Topsoil		.1		CL SANDY CLAY with considerable GRAVEL brown, Some roots.	
	Laterite		1.6		SC CLAYEY SAND with considerable GRAVEL Fine to medium grained sand, fine grained gravel, fines of low plasticity, red, moist Some roots; angular quartz fragments.	Medium Dense
30523	EW Mudstone		3.3		CH SANDY CLAY with a trace of GRAVEL High plasticity, fine grained sand, blue yellow red, bedded, moist, MC > PL Mudstone is blue with 70° dipping red and yellow beds; hard digging.	Very Stiff
					Pit terminated at 3.3m - refusal	

Logged by	R.P.B.D.	Date:	23.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ 17

Client:	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job No. 2306
Project:	RUM JUNGLE REHABILITATION PROJECT	R.L.

Equipment type: Backhoe
Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		CL SANDY CLAY some GRAVEL Low plasticity, brown, Some roots.	
	Laterite		.5		SC CLAYEY SAND with some GRAVEL Fine grained sand, fines of low plasticity brown, dry Some roots.	Dense
30524	Lateritic Clay		2.3		CH SANDY CLAY with a trace of GRAVEL High plasticity, fine to coarse grained sand red, moist, MC > PL	Very Stiff
	Lateritic Clay		3.2		CH CLAY some SAND some GRAVEL High plasticity, fine to medium grained sand fine to medium grained gravel, grey red and yellow, moist, MC > PL	Very Stiff
					Pit terminated at 3.2m - limit of reach, easy digging	

Logged by: R.P.B.D.	Date: 23.4.82	Checked by: J.J.A.	Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No.	RJ 19
Job No.	2306
Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Project :	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		CL SANDY CLAY some GRAVEL brown, Some roots.	
30525	Laterite		1.1		SC CLAYEY SAND with considerable GRAVEL Fine to coarse grained sand, fine grained gravel, fines of high plasticity, red, moist Some roots.	Dense
30526	Lateritic Clay		3.3		CH SANDY CLAY High plasticity, fine grained sand, red, moist MC > PL	Very Stiff 400 (kPa)
					Pit terminated at 3.3m - limit of reach, easy digging	

Logged by	R.P.B.D.	Date.	23.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job no 2306
Project RUM JUNGLE REHABILITATION PROJECT	RL

Pit: RJ 20

Equipment type: Backhoe
Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY SAND with considerable GRAVEL brown, Some roots.	
30527	Laterite		.5		SC CLAYEY SAND with considerable GRAVEL Fine to medium grained sand, fine grained gravel, fines of medium plasticity, red and yellow/brown, moist Some roots.	Dense
30528	Lateritic Clay		3.2		CH SANDY CLAY with a trace of GRAVEL High plasticity, fine grained sand, red, moist MC = PL EW mudstone at base of pit; hard digging.	Very Stiff
					Pit terminated at 3.2m - refusal	

Logged by R.P.B.D.	Date 23.4.82	Checked by: J.J.A.	Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 21

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Uranium Tailings		.2		SC CLAYEY SAND with considerable GRAVEL grey,	
	Alluvium	▼ (2.0)	2.0		CL GRAVELLY CLAY with considerable SAND Medium plasticity, fine grained gravel yellow/brown, wet. Easy digging Water table at 2m depth.	Firm
			2.5		Pit terminated at 2.5m - refusal	

Logged by	R.P.B.D.	Date	23.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no	RJ 22
Job no	2306
Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
	Colluvium		.4		GC CLAYEY GRAVEL with considerable SAND Fine to medium grained gravel, fine grained sand, fines of low plasticity, grey, dry	Medium Dense
	Laterite		.6		GC CLAYEY GRAVEL with some SAND Fine grained gravel, fines of low plasticity yellow brown, moist Some roots.	Medium Dense
	Laterite		1.6		SC CLAYEY SAND with considerable GRAVEL Fine to medium grained sand, fine grained gravel, fines of medium plasticity, red and yellow brown, moist	Medium Dense
30529	Lateritic Clay		3.9		CH SANDY CLAY some GRAVEL High plasticity, fine to medium grained sand red and yellow brown, moist, MC = PL Groundwater at base of pit.	Firm
					Pit terminated at 3.9 m - limit of reach, easy digging	

Logged by	R.P.B.D.	Date	24.4.82	Checked by:	J.J.A.	Date	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 13

Job no: 2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

R L

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		CL SANDY CLAY some GRAVEL brown, Some roots.	
30530	Lateritic Clay		.6		CL SANDY CLAY some GRAVEL Medium plasticity,fine grained sand yellow/brown,moist,MC < PL Some roots.	Stiff
	Laterite		1.3		SC CLAYEY SAND with considerable GRAVEL Fine to medium grained sand,fine grained gravel,fines of medium plasticity,red,moist Some roots.	Dense
30531	Lateritic Clay		2.6		CH SANDY CLAY with a trace of GRAVEL High plasticity,fine grained sand,grey red and yellow/brown,moist,MC > PL Some roots.	Stiff 250 (kPa)
	EW Mudstone		3.6		CL SANDY CLAY with considerable GRAVEL Medium plasticity,fine grained sand,grey red and yellow/brown,moist,MC < PL	Very Stiff 400 (kPa)
					Pit terminated at 3.6m - limit of reach,difficult digging	

Logged by	R.P.B.D.	Date	24.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

RJ 24

Job no. 2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with considerable GRAVEL brown, Some roots.	
	Lateritic Gravel				GC SANDY GRAVEL with considerable CLAY Fine grained gravel, fines of medium plasticity, red brown yellow brown mottled moist Some roots.	Dense
	Lateritic Clay		.5		CH SANDY CLAY with considerable GRAVEL High plasticity, fine grained sand, red blue and yellow, moist, MC = PL Some roots.	Stiff
	Mudstone		1.5		CL SANDY CLAY some GRAVEL grey blue, moist Fissured; hard digging.	Hard
			1.7		Pit terminated at 1.7m - refusal	

Logged by: R.P.B.D.	Date: 24.4.82	Checked by: J.J.A.	Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no: RJ 25

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
R L	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
30532	Lateritic Gravel		1.9		GC CLAYEY GRAVEL with considerable SAND Fine grained gravel, coarse grained sand fines of high plasticity, red and yellow brown, moist Some roots.	Dense
30533	EW Rock		3.3		CH SANDY CLAY some GRAVEL High plasticity, fine grained sand, grey red and yellow brown, moist, MC = PL Some roots; easy digging.	Very Stiff
					Pit terminated at 3.3m - refusal	

Logged by	R.P.B.D.	Date	24.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ 26

Client:	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No	2306
Project:	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY GRAVEL/SAND brown, Some roots.	
30534	Laterite		.9		SC CLAYEY GRAVEL/SAND Fine grained sand,fine grained gravel, medium plasticity clay,red and blue,moist Some roots.	Medium Dense
30535	EW Mudstone		1.2		CL SANDY CLAY some GRAVEL Medium plasticity,fine grained sand,fine grained gravel,red blue and yellow/brown infill clay on joints,moist,MC = PL Some roots.	Very Stiff
	Mudstone		1.7		CL SANDY CLAY some GRAVEL grey blue, Hard digging;bedrock.	

Pit terminated at 1.7m - refusal

Logged by	R.P.B.D.	Date	24.4.82	Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job no. 2306
Project: RUM JUNGLE REHABILITATION PROJECT	RL

RJ 27

Equipment type: Backhoe
Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		SC GRAVELLY SAND with considerable CLAY brown, Some roots.	
30536	Colluvium		.4		GW GC SANDY GRAVEL some CLAY Coarse grained gravel, medium grained sand fines of low plasticity, grey yellow, dry Some roots.	Medium Dense
30537	EW Granite		2,0		SC CLAYEY SAND with considerable GRAVEL Fine to coarse grained sand, fine grained gravel, fines of medium plasticity, red brown yellow brown mottled, moist Some roots.	Dense
	Granite		2.3		GRANITE - (MW - HW) grey, dry	Strong
					Pit terminated at 2.3m - refusal	

Logged by R.P.B.D.	Date 27.4.82	Checked by: J.J.A.	Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 28

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job no: 2306

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistancy Rel. Density Hand Penetrometer
	Topsoil		.1		CL SANDY CLAY some GRAVEL brown, Some roots.	
30538	Lateritic Clay		.5		CL SANDY CLAY with a trace of GRAVEL Medium plasticity, fine grained sand, red and yellow brown, moist, MC > PL Some roots.	Stiff 50 (kPa)
30539	Laterite		1.1		SC CLAYEY SAND with considerable GRAVEL Fine grained sand, fines of medium plasticity red and yellow brown, moist	Medium Dense
30540	Lateritic Clay		2.0		CH SANDY CLAY with a trace of GRAVEL High plasticity, fine grained sand, grey and yellow brown, moist, MC > PL Groundwater at base of layer.	Very Stiff
30541	EW Mudstone		3.7		SC CLAYEY SAND Fine to medium grained sand, fines of medium plasticity, grey and yellow brown, moist	Very Dense
					Pit terminated at 3.7m - limit of reach, easy digging	

Logged by: R.P.B.D. Date: 27.4.82 Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ 23

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job no. 2306
Project: RUM JUNGLE REHABILITATION PROJECT	R.L.

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SC GRAVELLY SAND with considerable CLAY brown, Some roots.	
30542	Laterite				SW SC GRAVELLY SAND some CLAY Fine to coarse grained sand, medium grained gravel, fines of low plasticity, yellow brown porous structure, moist Some roots; angular fragments.	Medium Dense
	EW Granite		.5		SP SC GRAVELLY SAND some CLAY Medium to coarse grained sand, fine grained gravel, fines of medium plasticity, grey red brown/yellow brown mottled, moist Some roots; angular quartz fragments.	Dense
	Granite		2.2		GRANITE (MW - HW), grey and yellow brown. Hard Digging	
			2.5		Pit terminated at 2.5m - refusal	

Logged by: R.P.B.D. Date: 27.4.82 Checked by: J.J.A. Date: 21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no. RJ 30

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no.	2306
Project:	RUM JUNGLE REHABILITATION PROJECT
R.L.	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY GRAVEL/SAND brown, Some roots.	
30543	Laterite		.6		SC CLAYEY GRAVEL/SAND Fine to medium grained sand, fine grained gravel, medium plasticity clay, red and yellow brown, moist Rounded fragments.	Dense
	EW Granite		1.3		SP SC GRAVELLY SAND some CLAY Fine to medium grained sand, fines of low plasticity, red white and yellow brown, moist Angular fragments.	Dense
	Granite		2.0		GRANITE - (MW - HW), grey, dry. Hard digging	
					Pit terminated at 2m - refusal	

Logged by	R.P.B.D.	Date	27.4.82
Checked by:	J.J.A.	Date:	21.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no	RJ 31
Job no	2306

Client MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT — RL

Equipment type: Backhoe
Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with considerable GRAVEL grey, Some roots.	
	Colluvium		.3		SC GRAVELLY SAND with considerable CLAY grey, Some roots.	
30544	EW Granite		1.5		SC CLAYEY SAND with some GRAVEL Fine to medium grained sand, fine grained gravel, fines of medium plasticity, red brown/yellow brown mottled with some white moist Some roots; difficult digging; mw/hw granite at base of pit.	Dense
					Pit terminated at 1.5m - refusal	

Logged by	R.P.B.D.	Date:	27.4.82	Checked by:	J.J.A.	Date:	25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No.	RJ 32
Job No.	2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

R L

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with considerable GRAVEL grey, Some roots.	
	Colluvium		.4		SC GRAVELLY SAND with considerable CLAY grey yellow, Some roots.	
	EW Granite		1.4		SC GRAVELLY SAND with considerable CLAY Fine to coarse grained sand,fine grained gravel,fines of medium plasticity,red brown/yellow brown mottled with some white moist Difficult digging; mw/hw granite at base of pit	Medium Dense
					Pit terminated at 1.4m - refusal	

Logged by: R.P.B.D. Date: 27.4.82 Checked by: J.J.A. Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no	RJ 33
Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		GC SANDY GRAVEL with considerable CLAY grey brown Some roots.	
30545	Lateritic Gravel		1.5		GC SANDY GRAVEL with considerable CLAY Medium grained gravel, fines of low plasticity, red yellow, dry	Dense
	Quartz Breccia		3		GC GRAVEL some SAND some CLAY Medium to coarse grained gravel, fines of medium plasticity, red brown, moist	Dense
	EW Rock		3.3		CL CLAY some SAND some GRAVEL Medium plasticity, brown and purple, moist, MC < PL Difficult digging.	Very Stiff
					Pit terminated at 3.3m - refusal	

Logged by R.P.B.D. Date 27.4.82 Checked by: J.J.A. Date: 25.5.82

Meehan Burgess & Yeate

Excavation Log

Excavation No: RJ 34

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job no: 2306
Project: RUM JUNGLE REHABILITATION PROJECT	RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SC GRAVELLY SAND with considerable CLAY grey brown, Some roots.	
	Colluvium		.6		GC SANDY GRAVEL with considerable CLAY grey brown, Some roots; angular gravel fragments	
30546	Lateritic Gravel		1.1		GC SANDY GRAVEL some CLAY Medium grained gravel, fines of medium plasticity, grey red and blue, moist Some roots; angular quartz fragments to 50mm..	Dense
	EW Rock		2.7		CL SANDY CLAY some GRAVEL Medium plasticity, fine to medium grained sand, grey blue, moist, MC < PL Difficult digging.	Hard
					Pit terminated at 2.7m - refusal	

Logged by: R.P.B.D.	Date: 27.4.82	Checked by: J.J.A.	Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no	RJ 35
Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job no 2306
Project: RUM JUNGLE REHABILITATION PROJECT	RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Tailings				CL SANDY CLAY grey,	
	Lateritic Clay		.3		CL GRAVELLY CLAY with considerable SAND Medium plasticity, fine grained gravel, yellow moist No free water at pit base after 36 hours.	Stiff
			2.3		Pit terminated at 2.3m - refusal	

Logged by: R.P.B.D.	Date: 27.4.82	Checked by: J.J.A.	Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No.	RJ 33
Job No.	2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

R.L.

Equipment Type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		SC GRAVELLY SAND with considerable CLAY grey brown, Some roots.	
	Colluvium		.6		GC SANDY GRAVEL with considerable CLAY grey brown, Some roots.	
30547	Laterite		1.5		SC GRAVELLY SAND with considerable CLAY Medium grained sand, fine grained gravel fines of low plasticity, red, moist Some roots; angular gravel fragments.	Dense
	EW Rock		3.5		ML SANDY SILT some GRAVEL Low plasticity, medium grained sand, red yellow with purple and white, moist, MC < PL Difficult digging.	Very Stiff
					Pit terminated at 3.5m - refusal	

Logged by: R.P.B.D. Date: 28.4.82

Checked by: J.J.A. Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ 37

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No.	2306
Project	RUM JUNGLE REHABILITATION PROJECT
R.L.	

Equipment type Backhoe

Excavation Dimensions 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SC GRAVELLY SAND with considerable CLAY grey brown, Some roots.	
30548	Laterite		.7		SC CLAYEY SAND with some GRAVEL Fine to medium grained sand, fine grained gravel, fines of medium plasticity, red, dry Some roots.	Dense
30549	Laterite		2		GC CLAYEY GRAVEL with considerable SAND Fine to coarse grained gravel, fine grained sand, fines of medium plasticity, red, moist Some roots.	Dense
	Lateritic Clay		3.6		CH CLAY some SAND some GRAVEL High plasticity, red yellow, moist, MC > PL	Very Stiff
					Pit terminated at 3.6m - limit of reach	

Logged by R.P.B.D. Date 28.4.82 Checked by: J.J.A. Date 25.5.82

Excavation Log

Excavation No.	RJ 38
Job No.	2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		CLAYEY GRAVEL/SAND grey brown, Some roots.	
30550	Laterite		.5		SC CLAYEY SAND with considerable GRAVEL Fine grained sand, fine to coarse grained gravel, fines of medium plasticity, yellow brown, dry	Dense
30551	Laterite		.8		SC GRAVELLY SAND with considerable CLAY Fine grained sand, fine to medium grained gravel, fines of medium plasticity, red blue moist	Dense
30552	Lateritic Gravel		1.5		GC SANDY GRAVEL with considerable CLAY Medium grained gravel, fine to medium grained sand, fines of high plasticity, red blue, moist	Dense
	Lateritic Clay		3.7		CH SANDY CLAY with considerable GRAVEL High plasticity, fine grained sand, red blue with yellow and black, moist, MC = PL Difficult digging.	Stiff
					Pit terminated at 3.7m - limit of reach	

Logged by: R.P.B.D. Date: 28.4.82

Checked by: J.J.A. Date: 25.5.82

Meehan Burgess & Yeate

Excavation Log

RJ 39

Client:	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project:	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		SC GRAVELLY SAND with considerable CLAY grey brown, Some roots.	
30554	Lateritic Gravel		.5		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, medium grained sand, fines of low plasticity, yellow, dry Some roots.	Dense
30553	Lateritic Gravel		1.3		GC SANDY GRAVEL some CLAY Fine to medium grained gravel, coarse grained sand, fines of medium plasticity, red yellow moist	Dense
	Lateritic Clay		2.5		CH SANDY CLAY some GRAVEL High plasticity, fine grained sand, red yellow moist, MC = PL	Very Stiff
	EW Rock		3.5		CL SANDY CLAY some GRAVEL Medium plasticity, fine grained sand, red yellow and white, moist, MC < PL	Hard
					Pit terminated at 3.5m - limit of reach	

Logged by R.P.B.D. Date 28.4.82 Checked by: J.J.A. Date: 25.5.82

Meehan Burgess & Yeate

Excavation Log

Excavation no. RJ 45

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no.	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe.
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		SC GRAVELLY SAND some CLAY grey, Some roots.	
	Laterite		.3		SC GRAVELLY SAND some CLAY Fine to medium grained sand, fines of medium plasticity, yellow, dry Some roots.	Medium Dense
30555	EW Granite		1.2		SC GRAVELLY SAND with considerable CLAY Coarse grained sand, fine grained gravel fines of low plasticity, red yellow and white discontinuous sand drains, dry Difficult digging.	Dense

Logged by	R.P.B.D.	Date	28.4.82
Checked by:	J.J.A.	Date:	25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no. RJ 41

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no.	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY SAND with some GRAVEL grey brown, Some roots.	
30557	Laterite		.6		SC CLAYEY SAND with some GRAVEL Fine grained sand, fine grained gravel, fines of low plasticity, red brown, dry Some roots.	Dense
30556	Lateritic Gravel		1.1		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, fine grained sand, fines of medium plasticity, red brown, dry Some roots; gravel fragments to 50mm..	Medium Dense
	EW Rock		1.7		SC GRAVELLY SAND some CLAY Medium grained sand, fine to medium grained gravel, fines of low plasticity, red yellow and white, moist Some roots.	Very Dense
	EW Rock		3.1		SC CLAYEY SAND with some GRAVEL Medium to coarse grained sand, fines of low plasticity, red brown/yellow brown mottled with some white, moist Difficult digging	Very Dense
					Pit terminated at 3m - refusal	

Logged by: R.P.B.D.	Date: 28.4.82	Checked by: J.J.A.	Date: 25.5.82

Meehan Burgess & Yeate

Excavation Log

Excavation no: RJ 42

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
R.L.	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		CLAYEY GRAVEL/SAND grey brown, Some roots.	
30558	Lateritic Clay		.8		CH SANDY CLAY with considerable GRAVEL High plasticity,fine to coarse grained sand yellow brown and blue,moist,MC < PL Some roots.	Stiff
30559	Lateritic Gravel		1.2		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel,coarse grained sand,fines of high plasticity,red blue and brown,moist	Dense
	EW Rock		3.5		CL CLAY some SAND some GRAVEL Medium plasticity,red brown/yellow brown mottled with some white,moist,MC = PL	Hard
	EW Rock		3.9		CL CLAY some SAND some GRAVEL Low plasticity,white,dry	Hard
					Pit terminated at 3.9 m - limit of reach	

Logged by: R.P.B.D.	Date: 28.4.82	Checked by: J.J.A.	Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 43

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job no: 2306

Project: RUM JUNGLE REHABILITATION PROJECT

R L

Equipment type: Backhoe
Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		GC SANDY GRAVEL with considerable CLAY grey brown, Some roots.	
	Colluvium		.4		GC SANDY GRAVEL with considerable CLAY Medium grained gravel, fines of low plasticity, red, dry Gravel particles to 100mm..	Medium Dense
30560	Lateritic Gravel		1.7		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, medium to coarse grained sand, fines of low plasticity red yellow, moist	Loose
30561	Lateritic Gravel		3.6.		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, fine grained sand, fines of low plasticity, yellow, moist	Medium Dense
					Pit terminated at 3.6m - limit of reach	

Logged by: R.P.B.D. Date: 28.4.82 Checked by: J.J.A. Date: 25.5.82

Excavation Log

Excavation No.	RJ 44
Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job No. 2306
Project: RUM JUNGLE REHABILITATION PROJECT	RL

Equipment type: Backhoe
Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY SAND with some GRAVEL grey, Some roots.	
30562	Laterite				SC CLAYEY SAND with some GRAVEL Coarse grained sand,fine grained gravel fines of low plasticity,grey,dry Some roots.	Medium Dense
	EW Rock		.8		SC GRAVELLY SAND some CLAY Coarse grained sand,fine grained gravel fines of low plasticity,red brown/yellow brown mottled with some white,moist Easy digging.	Medium Dense
			2		Pit terminated at 2m - refusal	

Logged by: R.P.B.D.	Date: 29.4.82	Checked by: J.J.A.	Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No.	RJ 45
Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no.	2306
Project	RUM JUNGLE REHABILITATION PROJECT
R.L.	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil				GC SANDY GRAVEL some CLAY grey brown, Some roots.	
	Lateritic Gravel		.3		GC SANDY GRAVEL some CLAY Fine grained gravel, coarse grained sand fines of low plasticity, red yellow, moist Angular gravel fragments to 50mm..	Very Dense
	Lateritic Clay		1.8		CH CLAY some SAND some GRAVEL High plasticity, yellow, moist, MC > PL	Very Stiff
	Lateritic Clay		2.4		CH SANDY CLAY some GRAVEL High plasticity, fine grained sand, red, moist MC < PL	Very Stiff
			3.9		Pit terminated at 3.9 m - limit of reach	

Logged by	R.P.B.D.	Date	29.4.82
Checked by:	J.J.A.	Date:	26.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No.	RJ 46
Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No.	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		GC CLAYEY GRAVEL with considerable SAND grey brown, Some roots.	
30563	Lateritic Clay		1.8		GC CLAYEY GRAVEL with considerable SAND Fine grained gravel,fines of high plasticity green brown,moist Some roots.	
30564	Lateritic Clay		3.8		CH SANDY CLAY some GRAVEL High plasticity,fine grained sand,green with some red white and yellow,moist,MC > PL Free water at 3.75m. after 15 minutes.	Firm
					Pit terminated at 3.8 m - limit of reach	

Logged by	R.P.B.D.	Date	29.4.82
Checked by:	J.J.A.	Date:	25.582

Meehan Burgess & Yeates

Excavation Log

Excavation No.	RJ 47
Job no.	2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		GC SANDY GRAVEL with considerable CLAY red brown, Some roots.	
	Quartz Breccia		1		GC SANDY GRAVEL some CLAY Coarse grained gravel, medium grained sand purple pink white and yellow, moist Gravel particles to 200mm..	Dense
30565	Lateritic Clay		2.6		CH CLAY some SAND some GRAVEL High plasticity, red brown/yellow brown mottled with some white, moist, MC > PL	Very Stiff
	EW Rock		3.7		CL SANDY CLAY with considerable GRAVEL Medium plasticity, fine grained sand, red yellow and white, moist, MC < PL Difficult digging.	Stiff
					Pit terminated at 3.7m - limit of reach	

Logged by: R.P.B.D. Date: 29.4.82

Checked by: J.J.A. Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 4[illegible]

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job No: 2306

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
30566	Alluvium		.3		GC CLAYEY GRAVEL with considerable SAND Fine grained gravel, fines of high plasticity grey, dry Trace of roots.	Medium Dense
	Lateritic Clay		2.5		CH SANDY CLAY some GRAVEL High plasticity, medium grained sand, red yellow, moist, MC = PL	Very Stiff
	Lateritic Gravel		2.8		GC SANDY GRAVEL some CLAY Medium grained gravel, coarse grained sand fines of medium plasticity, red brown/yellow brown mottled, porous structure, wet Free water at 2.77m. after 15 minutes; easy digging.	Loose
					Pit terminated at 2.8m - refusal	

Logged by: R.P.B.D. Date: 29.4.82

Checked by: J.J.A Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 43

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job No: 2305

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
	Colluvium		.4		GC SANDY GRAVEL some CLAY brown, Angular gravel fragments.	
	Quartz Breccia		1.6		GC SANDY GRAVEL some CLAY red yellow blue and white, dry Angular quartz fragments to 200mm.; difficult digging.	Dense
					Pit terminated at 1.6m - refusal	

Logged by	R.P.B.D.	Date:	29.4.82	Checked by:	J.J.A.	Date:	25.5.82

Meehan Burgess & Yeates

Excavation Log

RJ 50

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD. — Job no: 2306

Project: RUM JUNGLE REHABILITATION PROJECT — RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SANDY GRAVEL with a trace of CLAY brown, Some roots.	
30567	Colluvium				GC SANDY GRAVEL some CLAY Medium to coarse grained gravel, fines of low plasticity, brown, dry Some roots; angular gravel fragments.	Loose
30568	Lateritic Gravel		.5		GC SANDY GRAVEL with considerable CLAY Fine grained gravel, medium grained sand fines of medium plasticity, red, moist Rounded fragments.	Loose
	Laterite		1.8		SC GRAVELLY SAND with considerable CLAY Fine grained sand, fine grained gravel, fines of low plasticity, red yellow, moist Easy digging.	Medium Dense
			3		Pit terminated at 3m - refusal	

Logged by: R.P.B.D. Date: 29.4.82 Checked by: J.J.A. Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

Bore/Log No	RJ 51
Job no	2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with some GRAVEL brown, Some roots.	
	Laterite				SC CLAYEY SAND with some GRAVEL Medium grained sand, fines of low plasticity red, dry Some roots.	Medium Dense
33589	Lateritic Gravel		.4		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, fine grained sand, fines of low plasticity, red, dry	Medium Dense
	Laterite		.8		SC GRAVELLY SAND with considerable CLAY Fine to medium grained sand, fine grained gravel, fines of low plasticity, red, dry	Dense
	Lateritic Clay		1.4		CH CLAY some SAND some GRAVEL High plasticity, fine to medium grained sand fine to medium grained gravel, red blue black and yellow, moist, MC > PL Angular quartz fragments; difficult digging.	Stiff
			3.5		Pit terminated at 3.5m - refusal	

Logged by	R.P.B.D.	Date	29.4.82
Checked by:	J.J.A.	Date:	25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no: RJ 52

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.	Job no 2306
Project	RUM JUNGLE REHABILITATION PROJECT	R.L.

Equipment type: Backhoe
Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
30571	Laterite		.7		SC CLAYEY SAND with considerable GRAVEL Fine grained sand, coarse grained gravel fines of low plasticity, grey brown, dry Some roots.	Dense
30570	Lateritic Clay		1.7		CH CLAY some SAND some GRAVEL High plasticity, brown, moist, MC > PL	Very Stiff 450 (kPa)
	EW Rock		3.8		CL CLAY some SAND some GRAVEL Medium plasticity, red brown/yellow brown mottled with green and white, moist, MC < PL	Very Stiff
					Pit terminated at 3.8 m - limit of reach	

Logged by: R.P.B.D. Date: 30.4.82 Checked by: J.J.A. Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

RJ 53

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No.	2306
Project	RUM JUNGLE REHABILITATION PROJECT
R L	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
	Colluvium		.4		GC SANDY GRAVEL some CLAY Fine to medium grained gravel, fines of low plasticity, brown, dry Some roots.	Loose
	Lateritic Gravel		1.5		GC SANDY GRAVEL some CLAY Fine to medium grained gravel, fine grained sand, fines of low plasticity, red white porous structure, dry Angular quartz fragments; sub-rounded particles.	Medium Dense
	EW Rock		2.3		CL CLAY some SAND some GRAVEL Low plasticity, grey yellow/brown, moist, MC < PL Difficult digging.	Hard
					Pit terminated at 2.3m - refusal	

Logged by R.P.B.D.	Date 30.4.82	Checked by: J.J.A.	Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation no: RJ 54

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.2		GC SANDY GRAVEL with considerable CLAY brown, Some roots.	
	Colluvium		.6		GC GRAVEL some SAND some CLAY Fine to medium grained gravel, fines of low plasticity, red, dry Some roots; angular gravel fragments.	Medium Dense
30572	Lateritic Gravel		1.6		GC SANDY GRAVEL some CLAY Fine to medium grained gravel, medium grained sand, fines of low plasticity, red, moist Some roots; sub-rounded gravel fragments.	Medium Dense
30573	Lateritic Clay		3.9		CL SANDY CLAY with considerable GRAVEL Medium plasticity, medium grained sand, fine grained gravel, red yellow/brown, moist, MC = PL	Stiff 300 (kPa)
					Pit terminated at 3.9 m - limit of reach	

Logged by	R.P.B.D.	Date	30.4.82	Checked by:	J.J.A.	Date:	26.5.82

Excavation Log

RJ 55

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job no	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	

Equipment type Backhoe

Excavation Dimensions 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.3		CL SANDY CLAY some GRAVEL brown, Some roots.	
	EW Rock		2.5		SC CLAYEY SAND with some GRAVEL Fine grained sand, fines of low plasticity red brown/yellow brown mottled, moist Difficult digging.	Very Dense
					Pit terminated at 2.5m - refusal	

Logged by R.P.B.D. Date 30.4.82 Checked by: J.J.A Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ 58

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No.	230E
Project	RUM JUNGLE REHABILITATION PROJECT
R.L.	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
30574	Lateritic Gravel				GC CLAYEY GRAVEL with considerable SAND Fine to medium grained gravel, medium grained sand, fines of low plasticity, red, dry Some roots; angular fragments.	Loose
	Laterite		2.8		GC SANDY GRAVEL with considerable CLAY Medium grained gravel, medium grained sand fines of low plasticity, red yellow/brown, moist	Loose
			3.9		Pit terminated at 3.9 m - limit of reach	

Logged by R.P.B.D. Date: 30.4.82 Checked by: J.J.A. Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No: RJ 57

Job No: 2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with some GRAVEL brown, Some roots.	
30576	Laterite		1.1		SC CLAYEY SAND with some GRAVEL Fine grained sand,fine grained gravel,fines of low plasticity,red brown,dry Some roots.	Medium Dense
	Lateritic Gravel		3.5		GC SANDY GRAVEL some CLAY Fine to medium grained gravel,medium grained sand,fines of low plasticity,red,moist Some roots.	Medium Dense
					Pit terminated at 3.5m - limit of reach	

Logged by: R.P.B.D. Date: 30.4.82

Checked by: J.J.A. Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

RJ 55

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD. — Job No: 2306

Project: RUM JUNGLE REHABILITATION PROJECT — RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		CL SANDY CLAY some GRAVEL brown, Some roots.	
30577	Lateritic Gravel		1.1		GC CLAYEY GRAVEL with some SAND Fine to medium grained gravel, coarse grained sand, fines of low plasticity, red brown, dry Some roots.	Medium Dense
	EW Rock		3.5		CL SANDY CLAY some GRAVEL Low plasticity, fine grained sand, fine grained gravel, red brown/yellow brown mottled, moist, MC < PL Some roots.	Very Stiff
					Pit terminated at 3.5m - limit of reach	

Logged by: R.P.B.D. Date: 30.4.82

Checked by: J.J.A. Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

RJ 59

Job no. 2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil				GC SANDY GRAVEL with considerable CLAY red brown, Some roots.	
30578	Lateritic Gravel		.1		GC SANDY GRAVEL some CLAY. Fine to medium grained gravel, fines of low plasticity, red, dry Some roots; angular fragments to 50mm..	Medium Dense
	Lateritic Gravel		1		GC SANDY GRAVEL some CLAY Medium to coarse grained gravel, fines of low plasticity, red, dry Some roots; angular fragments to 150mm..	Medium Dense
			3.7		Pit terminated at 3.7m - limit of reach	

Logged by: R.P.B.D. Date: 30.4.82 Checked by: J.J.A. Date: 26.5.82

Meehan Burgess & Yeates

Excavation Log

[illegible]	RJ 62
Job no	2306

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Project: RUM JUNGLE REHABILITATION PROJECT — RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil		.1		SC CLAYEY SAND with some GRAVEL grey brown, Some roots.	
30579	Alluvium		.6		SC CLAYEY SAND with some GRAVEL Medium grained sand, fines of low plasticity yellow brown, moist Some roots.	Dense
30580	Lateritic Gravel		2		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel, fine to coarse grained sand, fines of medium plasticity, red blue yellow, moist Rounded fragments to 15mm..	Dense
	Lateritic Clay		3.3		CH CLAY some SAND some GRAVEL High plasticity, red blue yellow, moist, MC > PL	Very Stiff
	EW Rock		3.7		CL SANDY CLAY some GRAVEL Low plasticity, fine grained sand, red blue red and blue bands, moist, MC < PL Groundwater at 3.55m. depth.	Hard
					Pit terminated at 3.7m - limit of reach	

Logged by R.P.B.D. Date 1.5.82 | Checked by: J.J.A. Date: 25.5.82

Excavation Log

RJ 61

Client	MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.
Job No	2306
Project	RUM JUNGLE REHABILITATION PROJECT
RL	
Equipment type	Backhoe
Excavation Dimensions	600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil				SC CLAYEY SAND with some GRAVEL grey brown, Some roots.	
30581	Alluvium		.1		SC CLAYEY SAND Fine to medium grained sand,yellow brown,moist Some roots.	Medium Dense
	Alluvium		1		GC CLAYEY GRAVEL with some SAND Fine to medium grained gravel,fines of low plasticity,red brown/yellow brown mottled porous structure,moist Gravel fragments to 50mm..	Medium Dense
	Alluvium				SC CLAYEY SAND with some GRAVEL Fine to medium grained sand,fines of medium plasticity,yellow brown,moist	Dense
	EW Rock		2		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel,medium grained sand,fines of high plasticity,red brown/yellow brown mottled,porous structure moist Gravel particles to 50mm.; difficult digging.	Medium Dense
			3		Pit terminated at 3m - refusal	

Logged by R.P.B.D.	Date 1.5.82	Checked by: J.J.A.	Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. [illegible]

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job No. 2308

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		SC CLAYEY SAND with some GRAVEL red brown, Some roots.	
30582	Lateritic Clay				CL SANDY CLAY some GRAVEL Medium plasticity,fine to medium grained sand,red,dry Some roots.	Very Stiff
	Laterite		1.8 2.0		SC GRAVELLY SAND some CLAY Medium grained sand,fine to medium grained gravel,fines of low plasticity,red,moist Some roots; angular gravel fragments.	Dense
	Laterite		2.2		SC CLAYEY SAND with some GRAVEL Fine to medium grained sand,fines of low plasticity,red yellow,moist Some roots.	Dense
	Lateritic Gravel		3.2		GC SANDY GRAVEL with considerable CLAY Fine to medium grained gravel,fines of medium plasticity,red,moist Angular fragments.	Medium Dense
	EW Rock		3.5		GC SANDY GRAVEL some CLAY Fine to coarse grained gravel,fines of low plasticity,red brown/yellow brown mottled moist Gravel fragments to 100mm.; difficult digging.	Dense
					Pit terminated at 3.5m - refusal	

Logged by R.P.B.D. Date 1.5.82

Checked by: J.J.A. Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

RJ 63

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD. Job no. 2306

Project: RUM JUNGLE REHABILITATION PROJECT RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel Density Hand Penetrometer
	Topsoil				SC CLAYEY SAND with considerable GRAVEL brown, Some roots.	
			.2			
	Colluvium				SC GRAVELLY SAND with considerable CLAY red brown, Some roots.	
	Lateritic Gravel		.4		GC SANDY GRAVEL some CLAY Fine to medium grained gravel, fines of medium plasticity, red brown, moist Some roots.	Dense
	Lateritic Clay		.6		CH SANDY CLAY some GRAVEL High plasticity, fine grained sand, red, moist MC < PL Some roots.	Stiff
			1.9			
	Lateritic Gravel				GC SANDY GRAVEL with considerable CLAY Fine to coarse grained gravel, fines of high plasticity, red brown, moist Some roots; angular gravel fragments.	Dense
	Lateritic Clay		2.1		CH SANDY CLAY some GRAVEL High plasticity, red, moist, MC = PL Some roots.	Stiff
	EW Rock		3		CH, SANDY CLAY some GRAVEL. High plasticity, white, moist, MC < PL. Angular quartz fragments	Hard
			3.7		Pit Terminated at 3.7 m - limit of reach	

Logged by: R.P.B.D. Date: 1.5.82 Checked by: J.J.A. Date: 25.5.82

Meehan Burgess & Yeates

Excavation Log

Excavation No. RJ E4

Client: MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

Job No. 2306

Project: RUM JUNGLE REHABILITATION PROJECT

RL

Equipment type: Backhoe

Excavation Dimensions: 600 mm Bucket

Samples	Geological Profile	Water	Depth in metres	Graphic Log	Soil or Rock Type, Structure	Consistency Rel. Density Hand Penetrometer
	Topsoil		.2		CLAYEY GRAVEL/SAND brown, Some roots.	
30583	Laterite		1		SC GRAVELLY SAND some CLAY Fine to medium grained sand, medium grained gravel, fines of medium plasticity, red brown dry	Dense
30584	Laterite		1.5		SC GRAVELLY SAND with considerable CLAY Fine to coarse grained sand, fines of low plasticity, red, dry	Dense
	EW Rock		1.7		SC GRAVELLY SAND some CLAY Fine to coarse grained sand, red yellow with some blue and white, dry Difficult digging.	Very Dense
					Pit terminated at 1.7m - refusal	

Logged by: R.P.B.D. Date: 1.5.82

Checked by: J.J.A. Date: 26.5.82

Meehan Burgess & Yeates

RUM JUNGLE REHABILITATION PROJECT

ENGINEERING REPORT

MAY 1982

VOLUME II SOIL STUDIES

PART 2

IMPERVIOUS COVER DESIGN FOR OVERBURDEN HEAPS

Mining & Process Engineering Services

RUM JUNGLE REHABILITATION PROJECT

ENGINEERING REPORT - MAY 1982

PART 2 - ENGINEERING DESIGN OF REHABILITATION MEASURES

FOR WASTE DUMPS AND DRAINAGE STRUCTURES

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Meehan Burgess & Yeates

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RUM JUNGLE REHABILITATION PROJECT

ENGINEERING REPORT - MAY 1982

PART 2 - ENGINEERING DESIGN OF REHABILITATION MEASURES FOR WASTE DUMPS AND DRAINAGE STRUCTURES

1. INTRODUCTION

The Rum Jungle Rehabilitation Project will involve the removal, reshaping and rehabilitation of the various waste dumps within the Project Area. Detailed descriptions of the work to be carried out are contained in Volume I of this report.

This part of the report considers the engineering design of rehabilitation measures for the White's, Dyson's and Intermediate Overburden Heaps and Dyson's Open Cut. These measures involve:

* The design of stable side slopes for the Overburden Heaps
* The design of cover layers for the tops and sides of the Overburden Heaps
* The design of cover layers for Dyson's Open Cut
* The design of drainage structures for both the surface and surrounds of the waste dumps.

Contour plans of White's, Intermediate and Dyson's Overburden Heaps are shown on Figures D1 and D2.

2. DESIGN CRITERIA

The principal criterion underlying development of the designs outlined above was that the Rum Jungle Rehabilitation Works should provide structures, within relatively fixed budget limits, which will maintain their integrity for a period in excess of 100 years whilst at the same time provide protection against the generation of contaminants from within the waste heaps.

From this criterion or the principal objective of the design, a number of sub-criteria follow:

* Maximum usage to be made of existing natural materials.
* Borrow materials required for construction should be obtained from areas within a radius not greater than 10 km around the Project Area.

* Development of borrow areas and construction of the rehabilitation structures should not significantly damage the environment which already exists, and materials used should be relatively inert with respect to contaminant generation.

* Stable covers should generally reflect profiles similar to the naturally developed soil profiles of the area. These existing profiles are stable and support good vegetation cover.

* Wherever possible, covers should allow natural revegetation to occur by incorporation of an erosion protective layer and a topsoil horizon or other material which will be suitable for the maintenance of vegetative growth.

3. REHABILITATION MEASURES FOR OVERBURDEN HEAPS

As part of the rehabilitation programme, the outer slopes of the Overburden Heaps will be stabilised by the flattening of existing batter slopes and the development of capping layers, with integrated drainage structures.

The work involved in the outer slopes will comprise:

* The flattening of batters around the perimeters of the pile to slopes not exceeding 3 horizontal to 1 vertical

* The construction of a simple layered cover which will inhibit rainfall infiltration into the heaps and provide a site for revegetation to commence.

* The construction of stable drainage lines around the perimeters of the heaps and the development of stable drainage lines over the surfaces of the heaps to provide erosion protection and infiltration control.

These measures will be applied to the existing White's Overburden Heap and Intermediate Heap as well as the residual portion of Dyson's Overburden Heap.

3.1 Stabilisation of the Outer Slopes

From observations made of the White's Overburden Heap and the Intermediate Overburden Heap, it is apparent that one of the major sources of contamination results from the infiltration of rainwaters into the uncompacted side slopes of the heap and its re-appearance at the toe of the heap as springs carrying a significant contaminant load. Thus in developing the design of the covers for the slopes of the Overburden Heaps, consideration has been given to minimising the amount of infiltration into the slopes.

Effective control over infiltration will be achieved by construction of a cover of vegetation, topsoil and rockfill to provide an "interception and surface store" and an underlying layer of low permeability earthfill.

The interception and surface store should provide storage for the initial 20 to 30 mm of rainfall during any single storm. In the existing heaps, this rainfall penetrates rapidly through the outer layer because of the rough and porous nature of the layer. Water then progresses into the lower layers where it is then unavailable for loss through evapo-transpiration. By providing the interception and surface store and slopes which will allow for rapid rainfall runoff during rainstorms in excess of 30mm, the extent of infiltration into the heap will be minimised. As a consequence, the amount of contaminants transmitted to the surrounding environment will be considerably reduced from the existing levels.

Batter flattening is required to provide a stable slope suitable for the construction and continued functioning of the cover. This will involve the establishment of cut to fill slopes of 3 horizontal to 1 vertical with berms 5 metres wide at 9 metre vertical intervals. These berms will be sloping rather than horizontal. There will be regular turnouts on the berms to ensure that water flows away from the heaps. Runoff will be led off the heaps into rip-rap lined drainage channels at the toe of the heaps.

A typical cross section through a stabilised slope is shown on Figure D3. The approach with respect to the stabilisation of the slopes and the subsequent cover is essentially the same for each of the waste dumps.

On the edges of the heaps, especially where cutting and filling has been carried out, the outer 450mm layer of the reshaped surface will be compacted to a granular surface by vibratory roller. The aim of this activity is to provide a "filter" layer for the overlying gravelly clay material, to reduce the tendency for the clay soils to wash into voids of the underlying waste rock.

The gravelly clay layer overlying the compacted outer surface of the waste dump requires a thickness of 300 mm when compacted and will be overlain by 450mm of compacted gravel or rockfill with topsoil infill.

From the field investigation, detailed in Part 1, there are ample quantities of laterite and lateritic gravels with the desired soil properties available locally.

3.2 Stabilisation of the Top Surface of the Heaps

Slightly different design conditions prevail over the top surface of the Overburden Heaps. Over this surface it is essential that any rainfall runs off into well defined channels and does not have the opportunity to pond and thus infiltrate the heap.

In contrast to the sides of the heap however, the surface slopes are relatively smooth and there has already been a considerable degree of compaction due to the passage of mining equipment during the develop -ment of the heaps.

The design developed for the rehabilitation of the overburden heaps provides for a limited amount of recompaction where necessary of the upper surface to ensure that a granular tight rockfill surface exists. This will be overlain by a layer of clay, earth-rockfill and topsoil materials similar to the sides of the heap.

Thus, the design requires compaction of the upper surface to establish this granular smooth base before placement of the capping comprising a gravelly clay layer 300 mm thick. The uppermost surface of the cover will be formed by a layer of ripped earth-rockfill material 200 mm thick. This upper layer would not be compacted other than by bulldozer tracking and construction equipment and the topsoil would be loosely spread into the material.

To encourage interception of water and therefore minimise the potential infiltration into the pile, a vegetated topsoil cover will be provided with a capacity similar to that of the side slopes (about 20 to 30 mm of the initial rainfall). The underlying gravelly clay layer will have a relatively low permeability and thus the infiltration capacity will be rapidly reached during heavy rainfalls resulting in overland flow into the drainage control lines. Thus, for light rainfalls, infiltrating water will be trapped in the surface soils and vegetation whilst for heavy rainfall, most water would runoff into the drains.

4. COVER DESIGN FOR DYSON'S OPEN CUT

As part of the overall rehabilitation for the Rum Jungle Project Area, the Dyson's Open Cut will be backfilled by the heap leach pile followed by the tailings material. Once these materials are in place, waste rock will be transferred from the Dyson's heap to cover the tailings. After the overall designed shape has been achieved, a final cover will be constructed.

For the design, it has been assumed that during the selection process of the materials on Dyson's heap, the most contaminated portions of the waste and those zones which have the greatest potential to generate contaminants will be removed first. The material would be progressively dumped into Dyson's Open Cut with the overall height of each successive lift restricted to 9m to ensure that unacceptable differential settlements do not occur. Compaction of the material other than by the passage of construction equipment is not required and such an operation would be an unnecessary cost.

As the material is dumped into the open cut, it will be raised to predetermined survey lines to ensure that a simple mounded profile is developed. The shape of the heap as shown on the cross sections, Figures D7 to D20, will provide a stable heap with rapid runoff of waters rather than infiltration into the dumped rock materials.

The upper 450mm, i.e. the last lift of dumped rockfill materials will be compacted to establish a granular, relatively smooth surface which will act as a "filter bed" on the upper surface of the heap. This compaction will be achieved by a smooth drum vibratory roller.

The actual cover design and surface treatment above this will comprise:

* A lateritic gravelly clay layer of low permeability (300 mm compacted thickness) whose purpose is to minimise infiltration into the heap. The clay, during rainfalls of 20 to 30 mm, will allow the water to perch in and above the clay layer rather than infiltration. Disposal of storms of greater than 20 to 30 mm will be by saturation of the cover and surface runoff into rip-rap lined drains around the perimeter.

* A layer 300 mm thick of fine rock rip-rap material infilled with top-soil; this layer will be compacted only by the passage of bulldozers and spreading equipment and will contain sufficient voids for the topsoil to infiltrate and establish a bed for subsequent growth.

On completion, the upper surface of Dyson's heap will slope at about 1 vertical to 8 horizontal, blending into the natural surface on either side of the heap with a rip-rap lined drain on the uphill side. A typical section is shown on Figure D4.

The objective of the final treatment of the Dysons heap is to provide a stable revegetated surface resistant to erosion and scouring. The surface will be revegetated to ensure a maximum interception and evapo-transpiration of light rainfalls rather than permitting infiltration into the heap. It is expected that the first 20 to 30mm of rainfall will be absorbed by the upper layers and any moisture penetrating to the underlying rockfill will be insufficient to cause significant contaminant generation in the rock materials which are used for filling the Open Cut.

Further, the first materials to be placed into Dyson's Open Cut will be the heap leach material and the tailings from the Old Tailings dam. The majority of this material which has a high potential for contaminant generation will be placed below the water surface so that rainwaters which penetrate through the cover and into the underlying rock materials will tend to cause oxidation in the more inert portion of the rock from Dysons heap before penetrating to the level of the tailings and heap leach material.

Material requirements in terms of volumes are summarised on Table 1 while required cover thicknesses and material properties are given on Table 2.

5. DESIGN OF DRAINAGE STRUCTURES

For the rehabilitation works, there will be essentially two types of drainage structures:

* Collector drains on the surface of the overburden heaps

* Catch drains at the foot of the overburden heaps.

5.1 Collector Drains on the Surface

The final surfaces of the Overburden Heaps will be shaped with grades of 0.5 to 1% falling towards collector drains. The gradients of the major drainage lines will vary from 1 to 10%. The required capacity of the drains increases with decreasing elevation as additional catch drains, formed in a dendritic pattern on the top of the heap, discharge their waters.

As a consequence, the design adopted for the main collector drains varies along the lengths of the drains. In the upper part of the catchment where the collecting area is less than about 2 ha, it will be sufficient to excavate and form definite drainage lines on the existing heap and to carry out recompaction at the base of the drains to enable runoff of the stormwaters without erosion.

With increasing catchment area, the capacity of the drains will be increased and, in order to minimise the effects of erosion and scour, a series of drop structures will be formed by PVC coated gabion retaining bunds. Reno mattresses will be used to form spillways at main outfalls to the local river system. A successful application of gabions in a similar environment is shown on Figure D6, whilst Figure D5 shows typical design details of the proposed gabion structures. This design has been adopted because of the long term erosion requirements and the need to control the cost of structures.

Initially, the bunds will be free standing and any water impounded behind the bunds will readily pass through the highly permeable rockfilled baskets, thereby minimising erosional velocities down the channel. Gradually during the establishment of vegetation on the heap, the bunds will collect any erosion products so that the risk of carrying suspended sediment into the Finnis River is minimised.

By providing a silt trap to collect any erosional products off the surface of the heap, the bunds will tend to revegetate naturally and thereby provide a vegetation or tree lined water course in the centre of the heap.

PVC coated gabions are produced especially for corrosive environments. However, if during the 100 year life of the erosion protection measures, the wire forming the gabion bunds should corrode, it is expected that the remaining pile of rocks and revegetated channel will be sufficient to retain sediment.

Other advantages of using gabions in the design are:

* <u>Flexibility</u>
  The use of gabions will enable the walls to be constructed even on reformed parts of the stockpile without undue need for foundation preparation. The gabions can, without loss of structural efficiency, deform or bend rather than crack or collapse under alternating tension or compression or in the event of ground subsidence.

* Permeability
Gabions exhibit a high degree of permeability which will allow not only collection of silt but will also act in effect as a series of retardation basins which will not pond the water and allow it to penetrate into the centre of the overburden heaps.

* Costs
The cost of construction of gabions and their transport to the site is considerably cheaper than other measures needed to control erosion in the centre of the gully, such as concrete.

* Width of Drainage Channel
By using gabions rather than excavated channels with rock retaining embankments, the width of the central drainage channels can be minimised and thereby allow greater vegetation cover in the main channel.

5.2 Catch Drains at the Foot of the Overburden Heaps

A significant source of pollution and environmental degradation occurs around the perimeter of the overburden heaps where the emerging acidic seepage waters has led to the destruction of root systems of the vegetation which formerly stabilised the creek channels. With destruction of the root structure, the channels widened to the extent that large areas are now devoid of vegetation and exhibit erosion.

A series of catch drains at the toe of each of the rehabilitated slopes will be constructed to collect the runoff from the slopes as well as any residual seepage waters and lead it through rip-rap lined channels into the main water courses where the potential for degradation will be lessened.

A typical section through such a lined catch drain is shown on Figure D3. The stability of these drains will be provided by their rocky nature and their degree of entrenchment below the surrounding ground surface. The capacity of the catch drains will be sufficient to ensure that overland flow of waters which either runoff from the waste dump or flow from it in the form of residual seepage does not occur. This will restrict the area where runoff waters and seepage waters from the waste dumps occurs, thus permitting revegetation of the previously damaged areas to take place naturally.

Figure D4 shows a catch drain above the rehabilitated Dyson's Open Cut. This drain is to intercept runoff from the hillside above Dyson's and redirect flow around the Open Cut. This drain, due to its elevation above the surrounding countryside, may require some gabions to form energy dissipators.

6. LIFE OF REHABILITATION MEASURES

As mentioned in Section 2 - Design Criteria - the principal criterion underlying development of the designs outlined is that the works should provide structures which will maintain their integrity for a period in excess of 100 years.

For the designs described above in this section of the report, we have attempted to provide this stability by incorporating the following features:

* A soil profile similar to that which exists in the natural surface already, i.e. a loosened topsoil layer with limited infiltration capacity, armoured by rock and rip-rap to provide against scouring and concentrated erosion, with an underlying clay layer simulating that which naturally occurs (at a depth of about 1 to 1.5m).

* The encouragement of vegetation wherever possible to provide for the stabilisation

* The development of drainage channels lined with natural rock materials which, even if they do erode will only provide distinct channels of erosion rather than widespread removal of the topsoil cover.

Thus, the stability of the cover in the long term depends on a natural soil profile and the development of vegetation. Whilst histororical records of the Darwin region are not sufficient to assess how long the measures will actually work, we have observed 900 year old man made slopes in Cambodia. The climate is similar to Darwin and these slopes, which form large water retaining structures, are still functioning. Their stability through 900 years of alternating wet and dry monsoonal climate has been provided by the development of vegetation. It is worth noting that the slopes have a gradient in excess of 3 horizontal to 1 vertical.

Thus, we believe that under the conditions which prevail at the Rum Jungle site, the measures provided will give this stability for the cover.

MATERIAL	LOCATION			TOTAL (m^3)
	WHITE'S OVERBURDEN (m^3)	INTERMEDIATE OVERBURDEN (m^3)	DYSON'S OPEN CUT (m^3)	
Compacted Gravelly CLAY	69,000	19,000	18,000	118,000
Loosely Compacted Lateritic GRAVEL or ROCKFILL with topsoil infill	57,000	17,000	-	86,000
Fine RIP RAP with topsoil	-	-	18,000	18,000
Fine RIP RAP for drains	1,000	500	1,200	3,300

RUM JUNGLE REHABILITATION PROJECT

TABLE 1 - QUANTITIES OF REQUIRED MATERIALS

Location	Cover Material	Thickness mm	Slope H:V	Compaction	Material Type	Properties P.I.	L.L.
Dyson's Open Cut	Topsoil/Rip-Rap	300	Varies	Construction Equipment	Ripped Sandstone	N/A	N/A
	Gravelly Clay	300	(Max) 4:1	90% Standard	Lateritic Gravelly Clay	30	45
	Waste Rock Top Surface	450		2 passes Vibratory Roller		N/A	N/A
Outer Edges of Overburden Heaps	Topsoil/Rip-Rap	450	3:1	Construction Equipment	Ripped blasted sandstone, inert waste	N/A	N/A
	Gravelly Clay	300	3:1	90% Standard	Lateritic Gravelly Clay	25	40
	Waste Rock Top Surface	450		2 passes Vibratory Roller		N/A	N/A
Top Surface of Overburden Heaps	Topsoil/Rip-Rap	200	Varies Maximum	Construction Equipment	Lateritic gravel Ripped Granite	10	25
	Gravelly Clay	300	8:1	90% Standard	Lateritic clay Weathered phyllite	25	40
	Waste Rock Top Surface	450		2 passes Vibratory Roller		N/A	N/A

TABLE 2 - RUM JUNGLE REHABILITATION PROJECT - COVER DESIGN

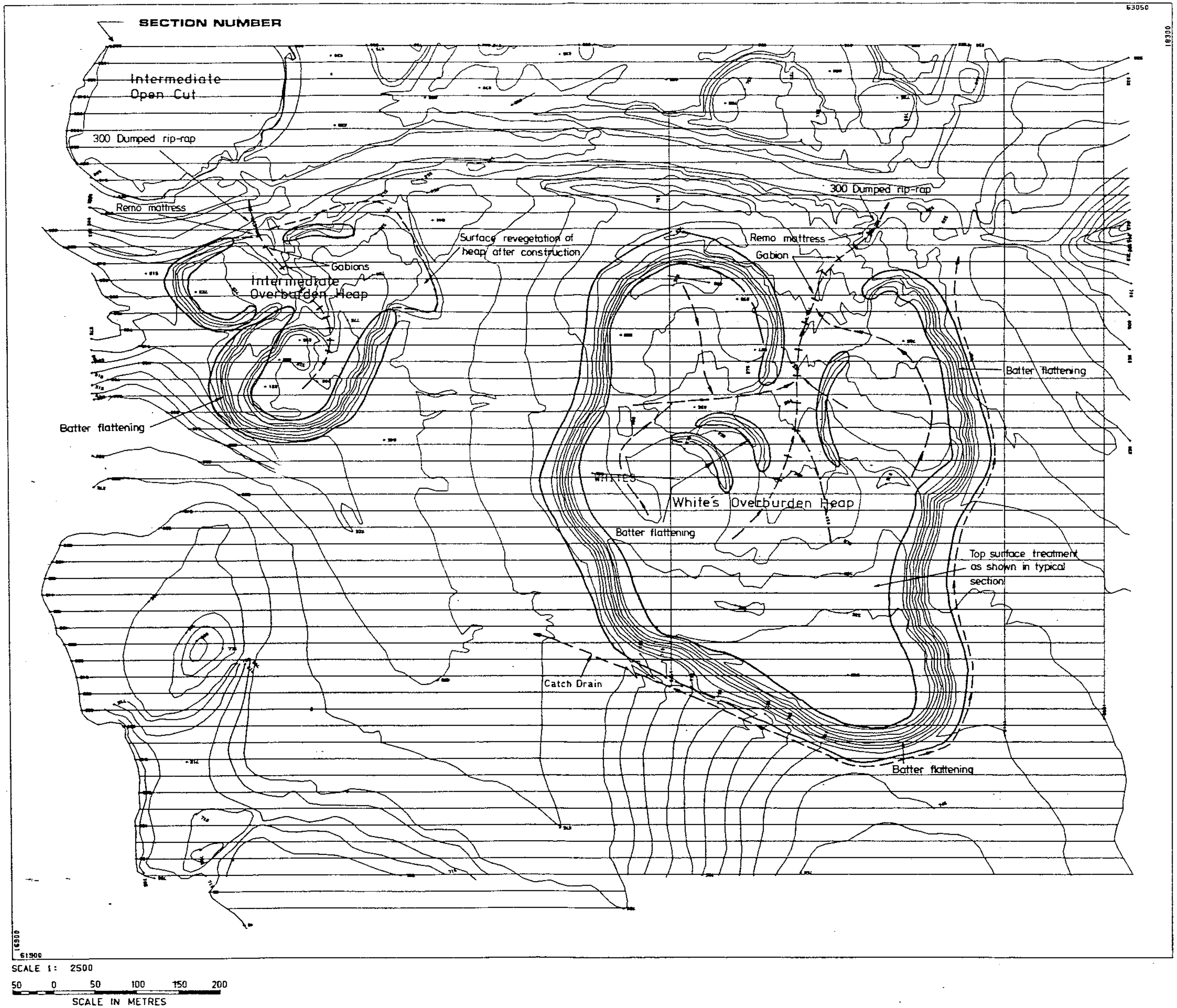

Figure D 1

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TITLE: RUM JUNGLE REHABILITATION KEY PLAN - WHITE'S / INTERMEDIATE

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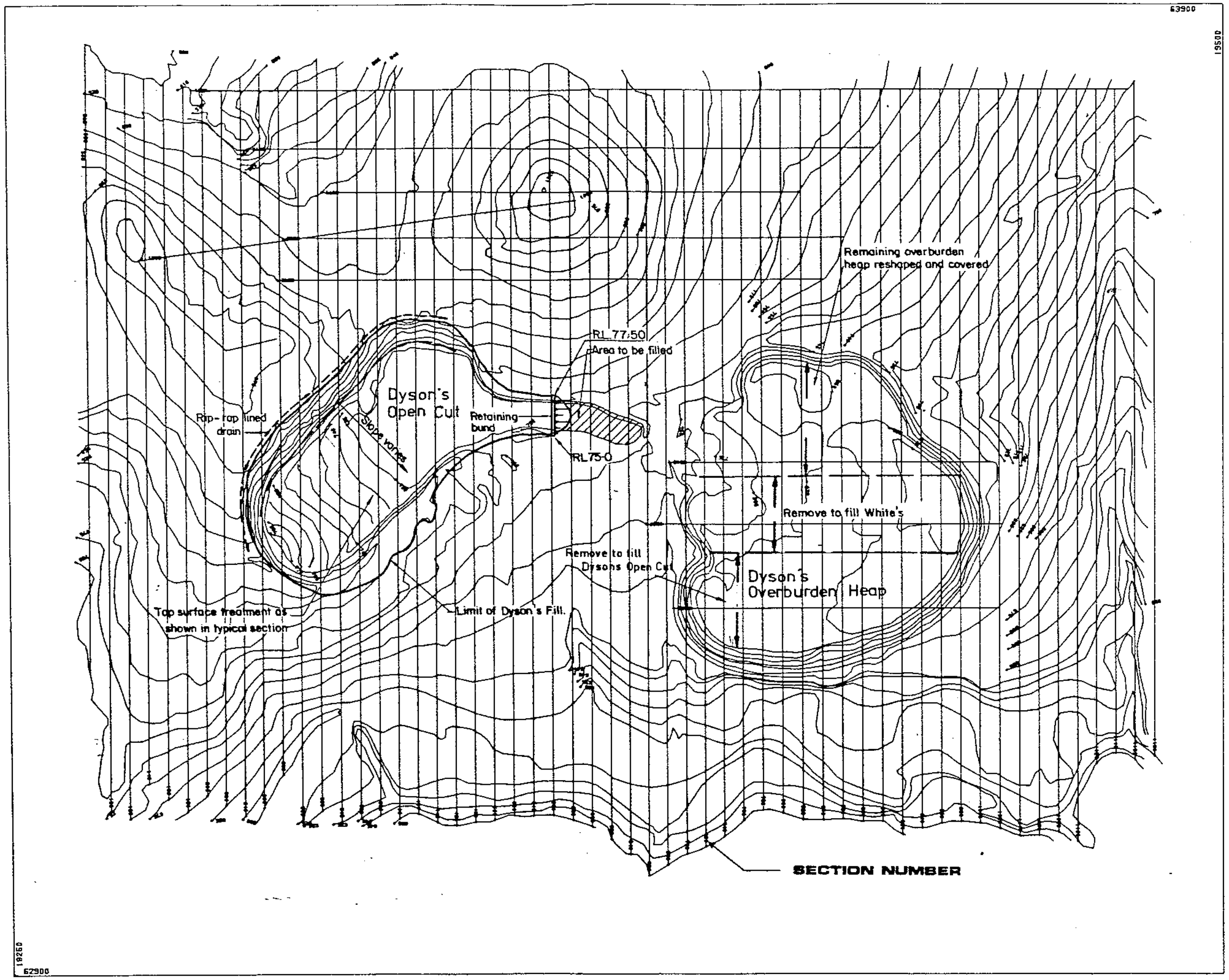

SCALE 1: 2500

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SCALE IN METRES

Figure D 2

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CLIENT	DEPT. OF TRANSPORT & WORKS (N.T.)
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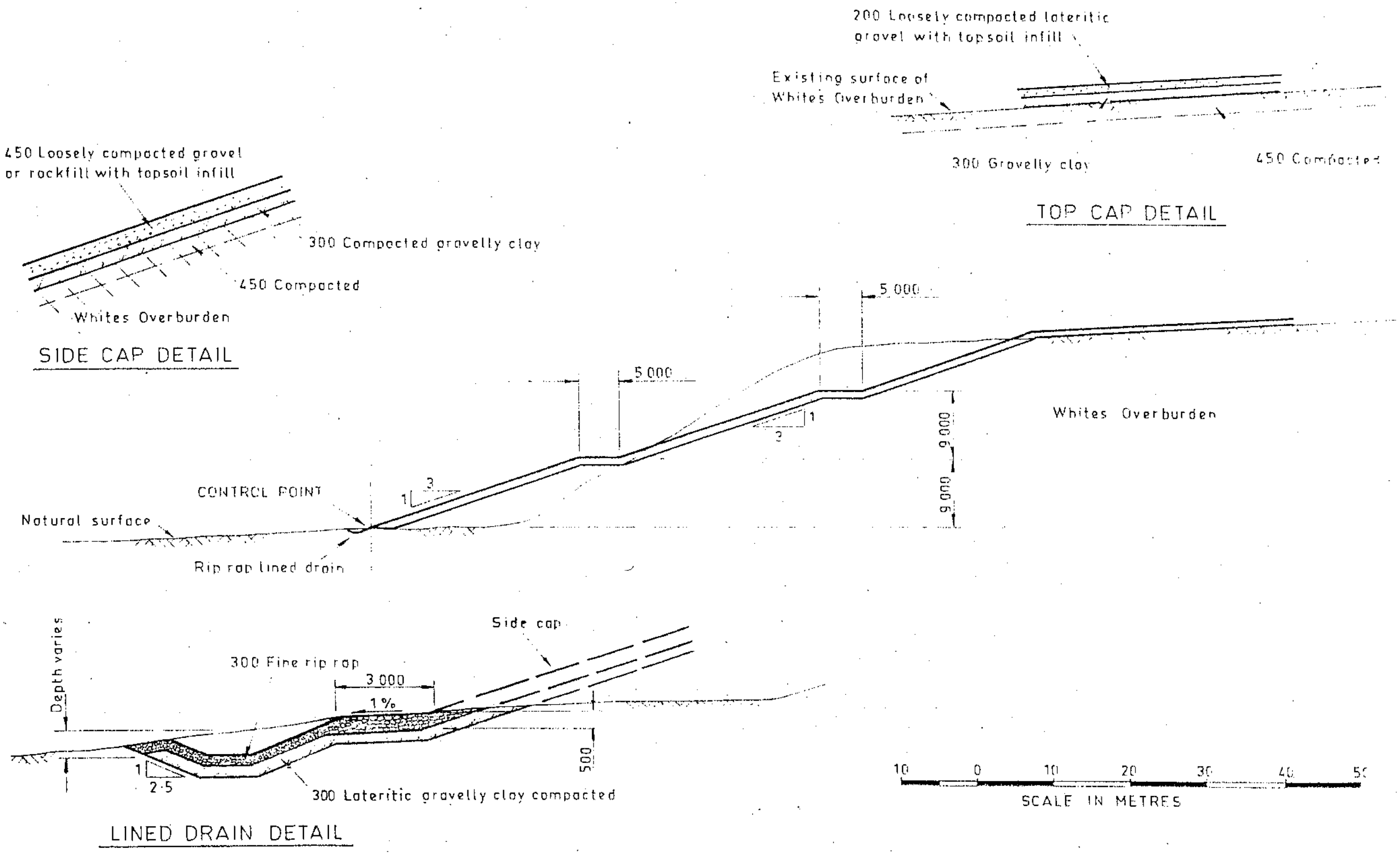

FIGURE D3

Revisions	Date

TYPICAL SECTION
TREATMENT OF WHITES OVERBURDEN
AND INTERMEDIATE OVERBURDEN

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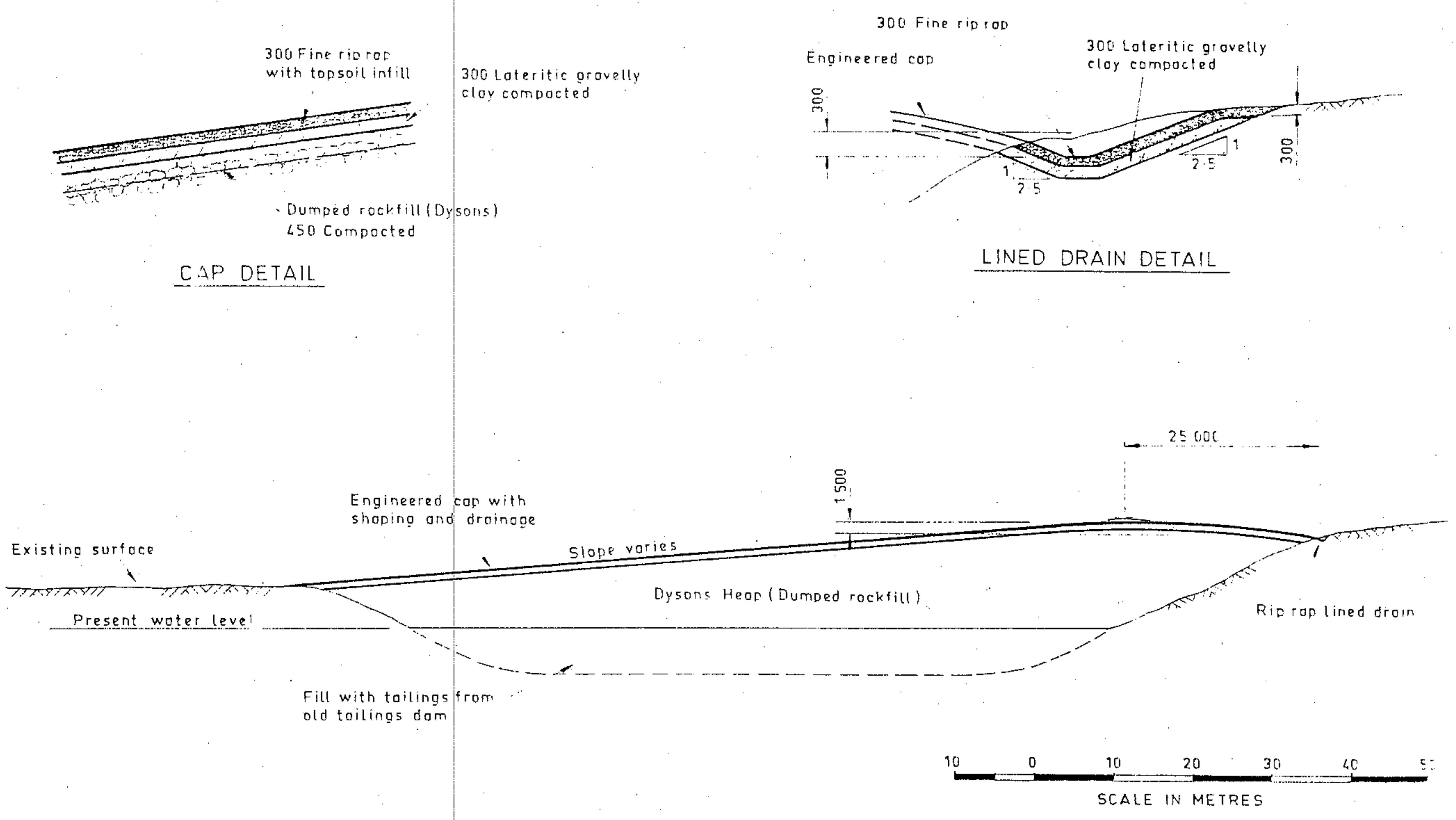

FIGURE D4

Revisions	Date

TYPICAL SECTION
TREATMENT OF DYSON'S HEAP

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DRG N° 2306 - 002

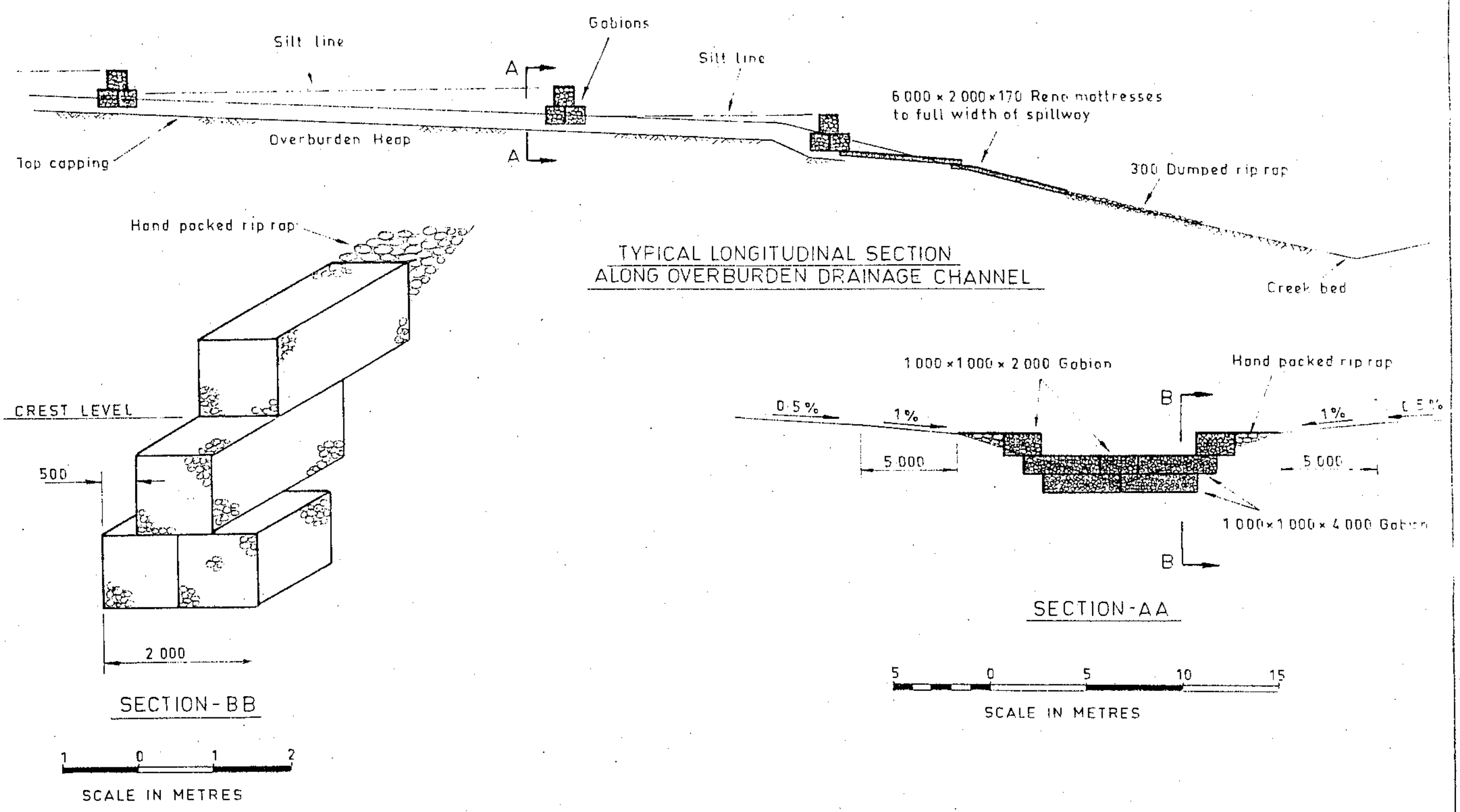


FIGURE D5

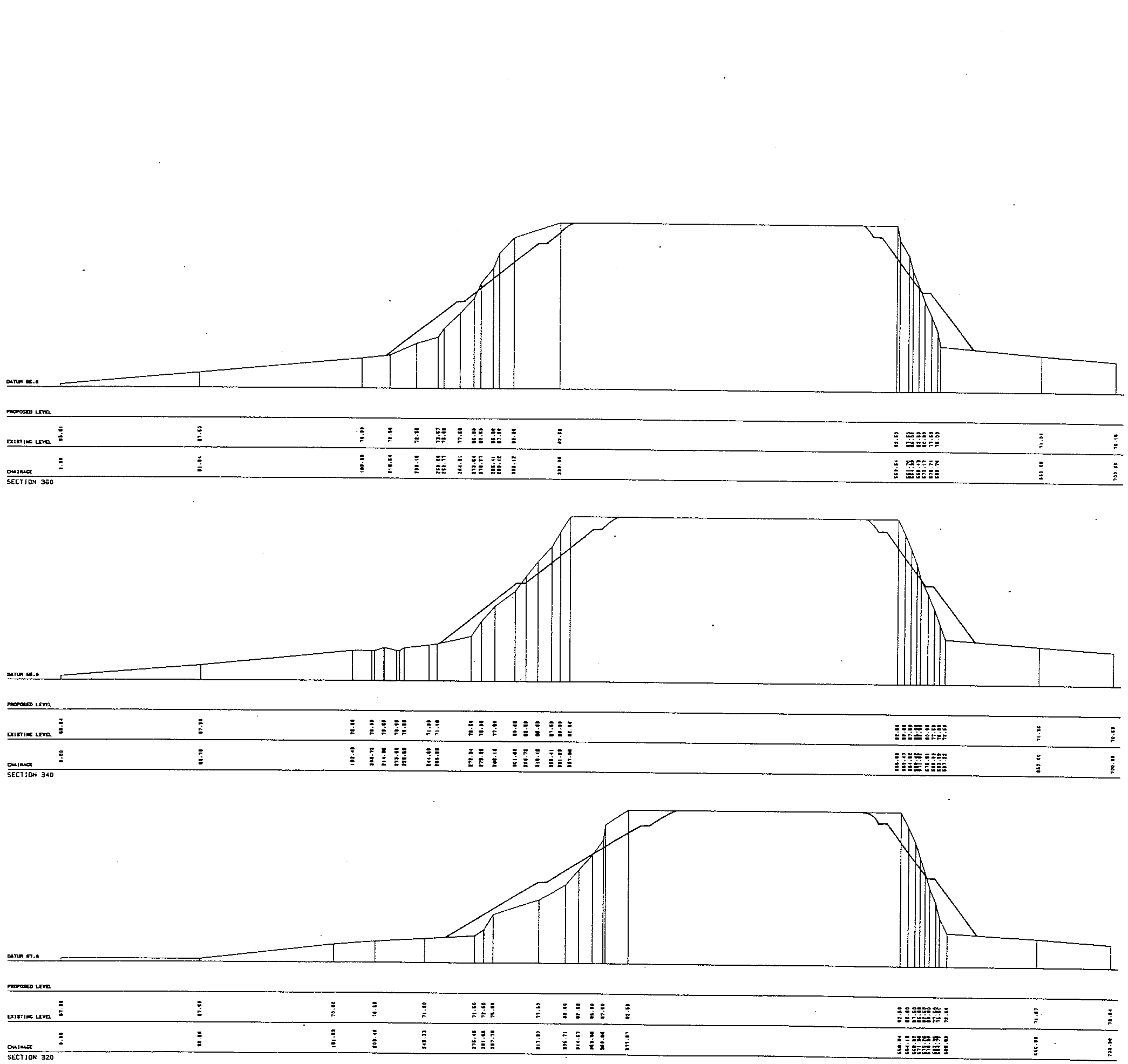
	Date
Revisions	

TYPICAL SECTIONS
OVERBURDEN DRAINAGE CHANNEL DETAILS

Meehan Burgess & Yeates | DRG. N° 2306-006

A series of small check dams preventing erosion in a gully.

Figure D 6



WHITE'S

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RUM JUNGLE REHABILITATION

WHITE'S OVERBURDEN - TYPICAL SECTIONS

A0 | HORIZ 1:1000 | VERT 1:250

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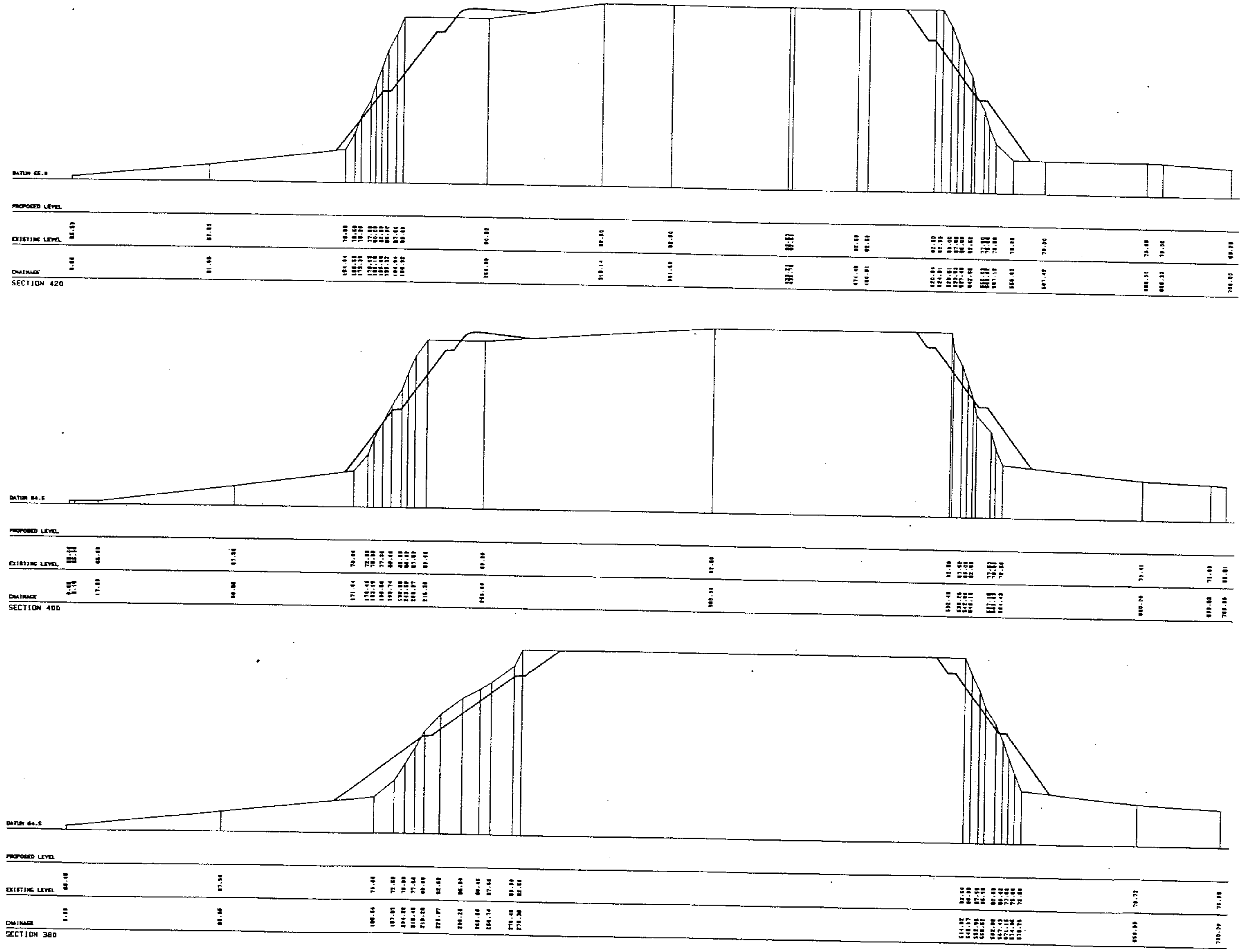

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WHITE'S OVERBURDEN - TYPICAL SECTIONS

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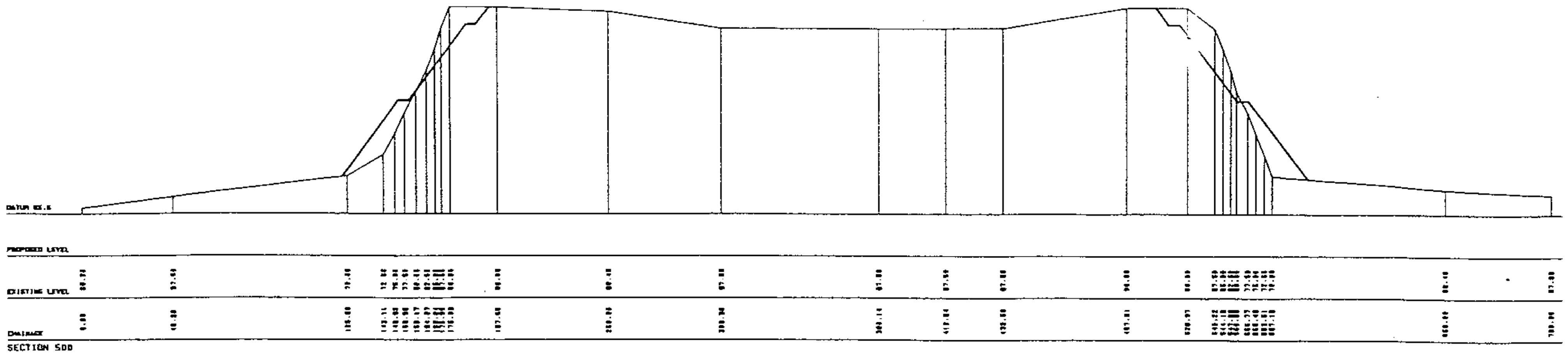

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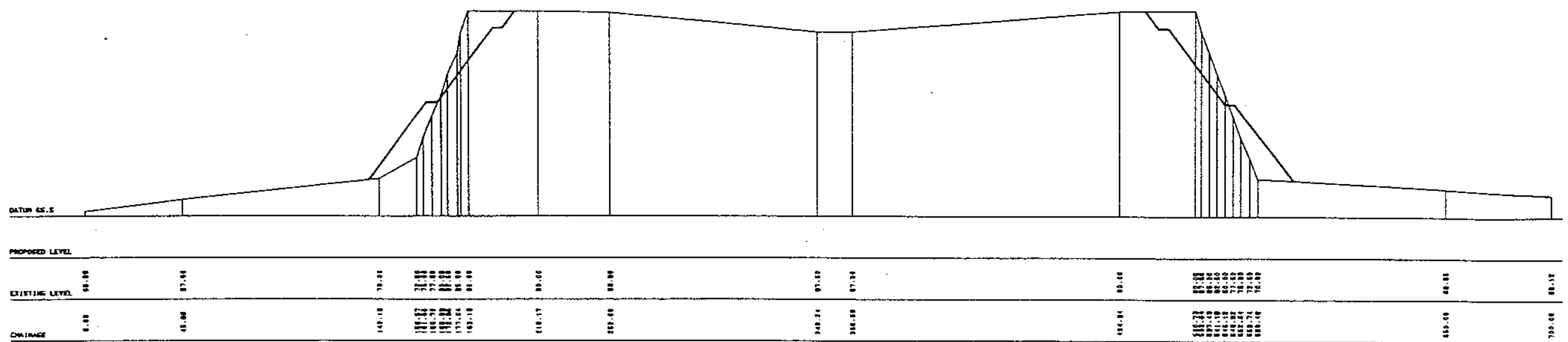

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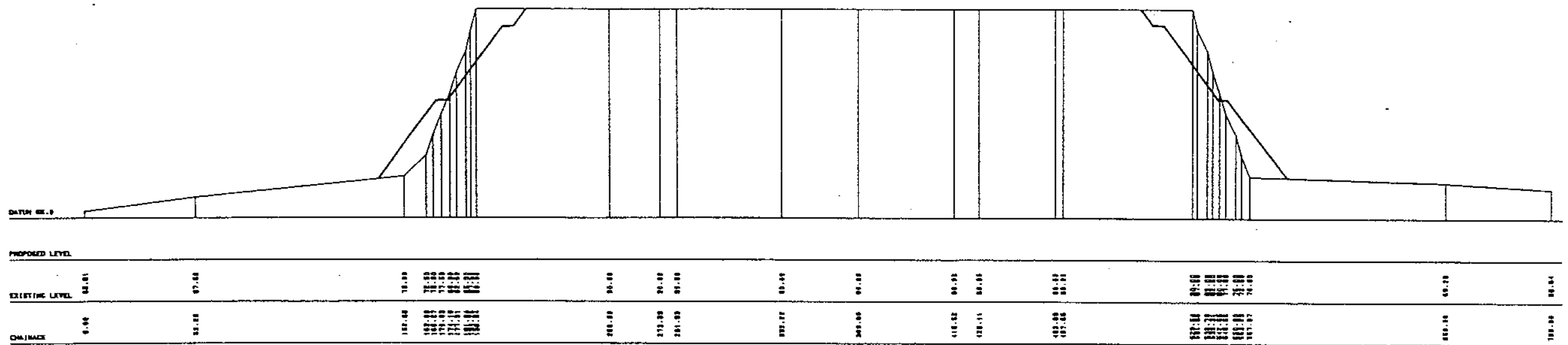

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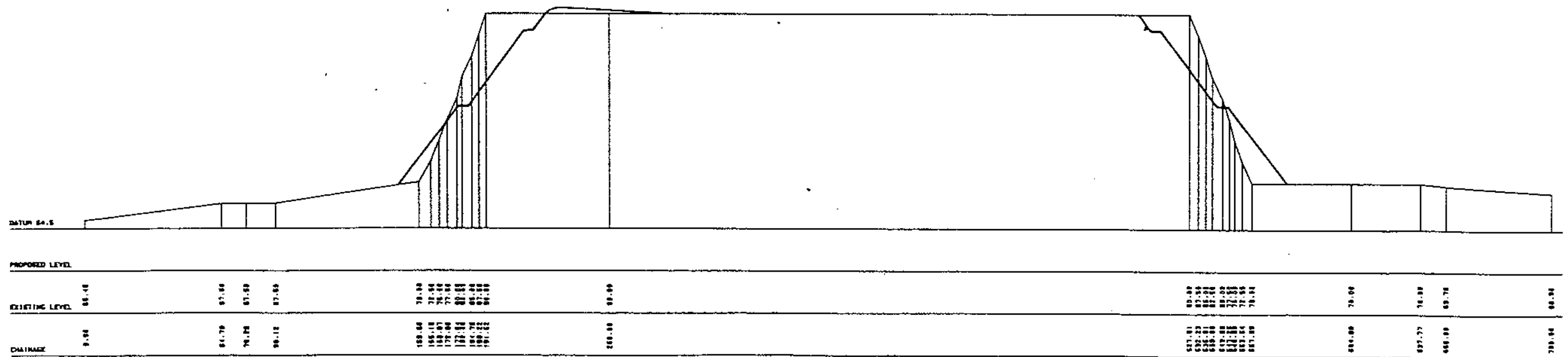

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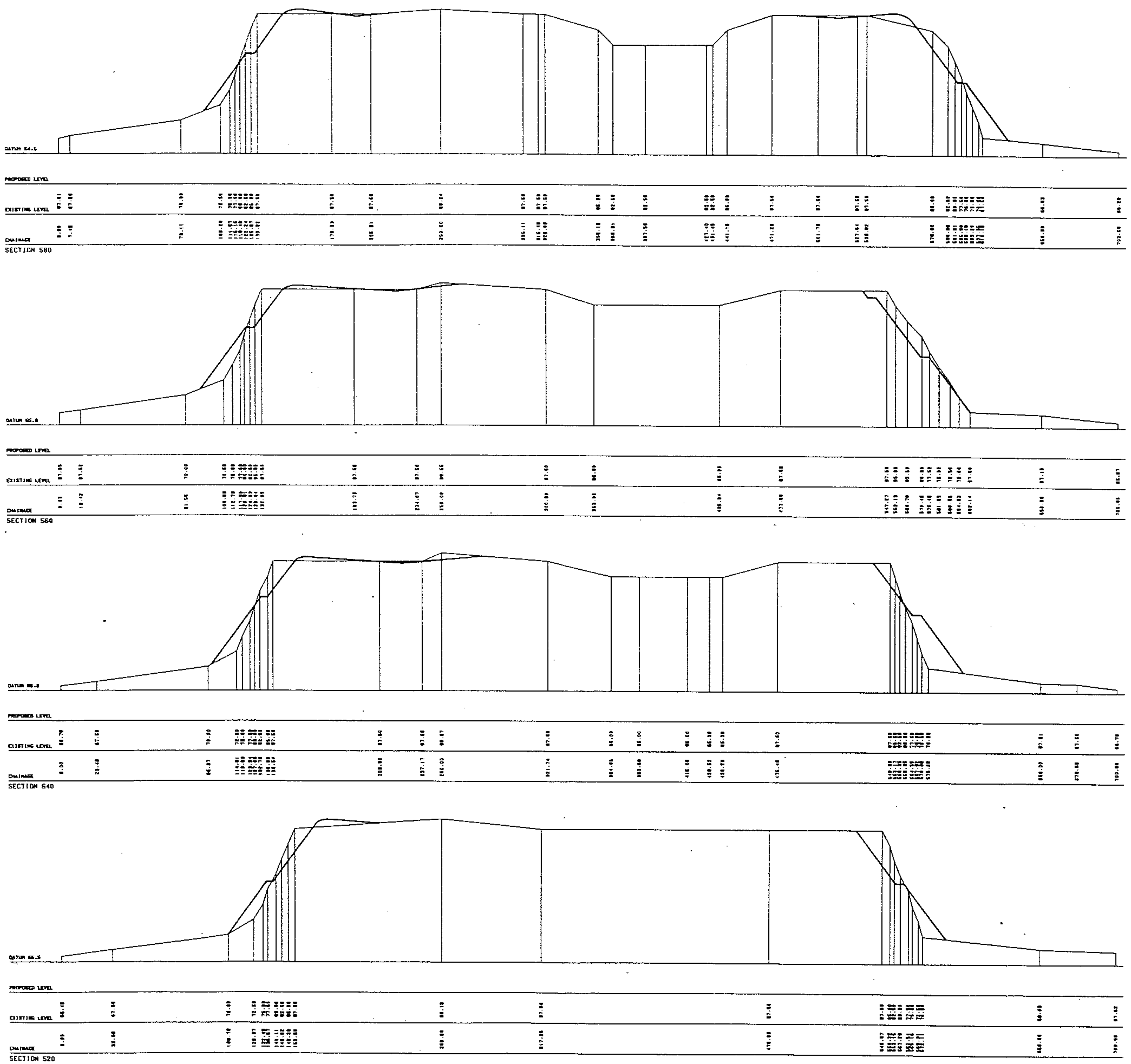

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WHITES OVERBURDEN- TYPICAL SECTIONS

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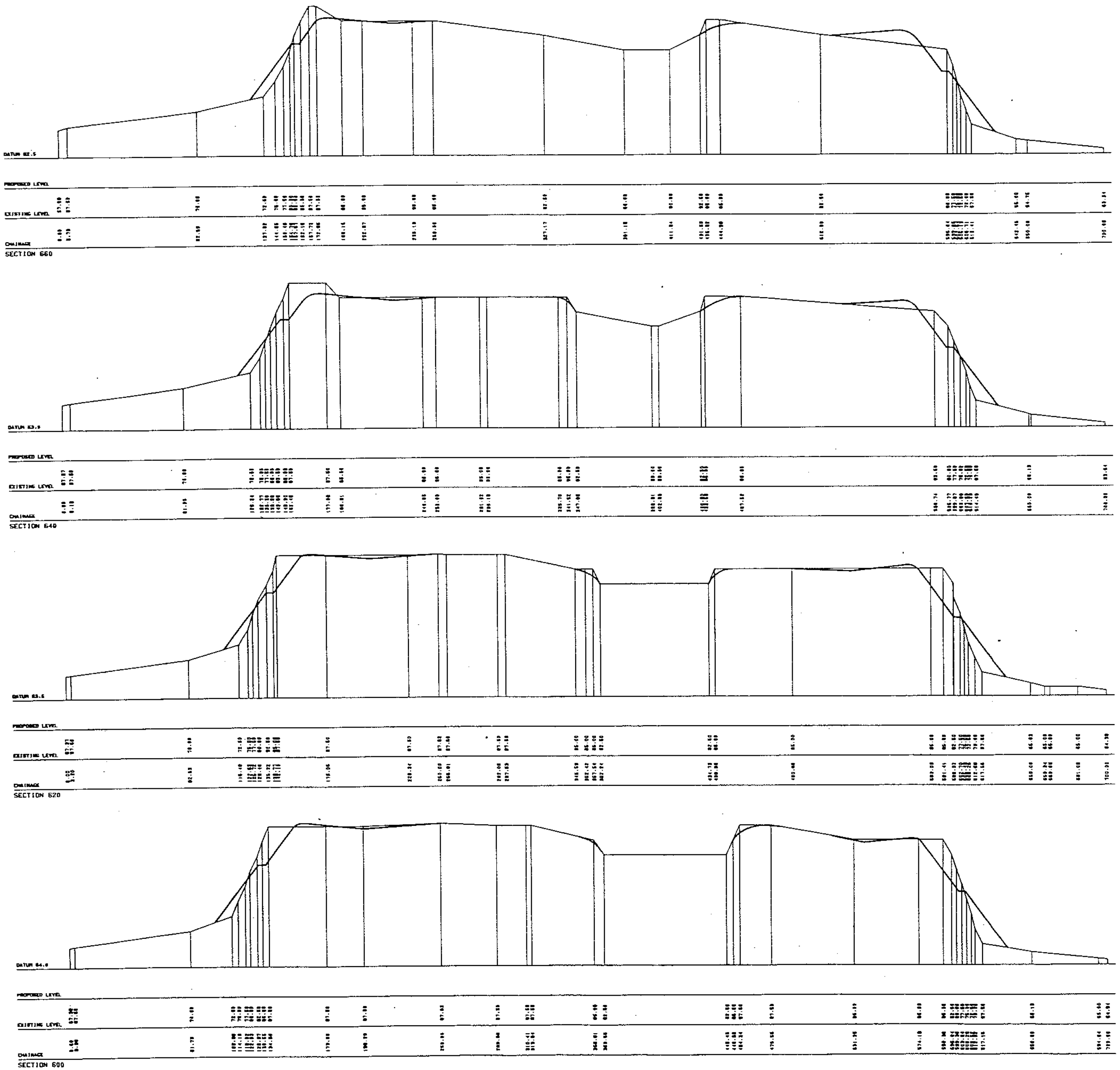

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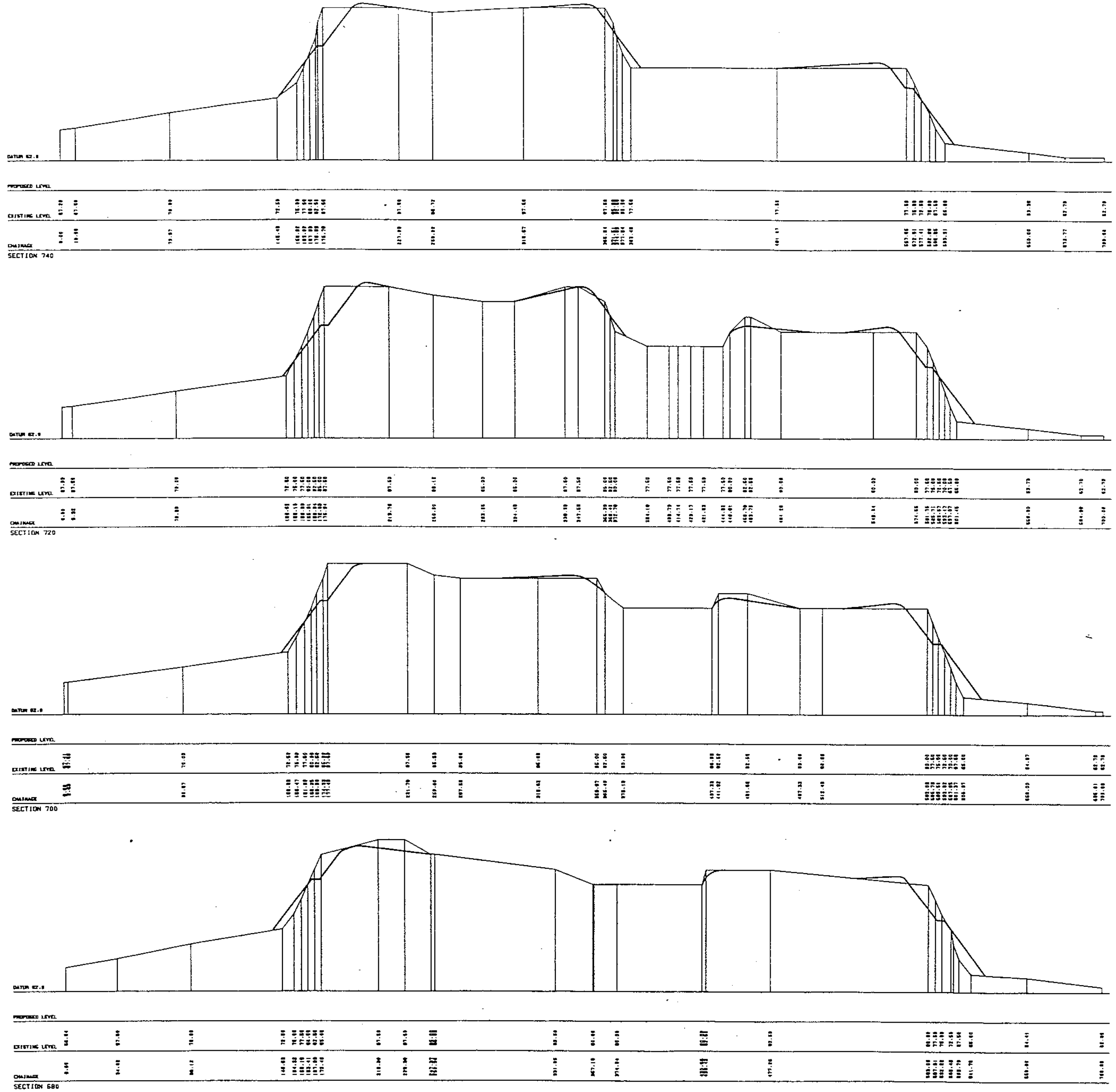

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RUM JUNGLE REHABILITATION
WHITE'S OVERBURDEN - TYPICAL SECTIONS

WHITE'S

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SCALE HORIZ 1:1000 VERT 1:200

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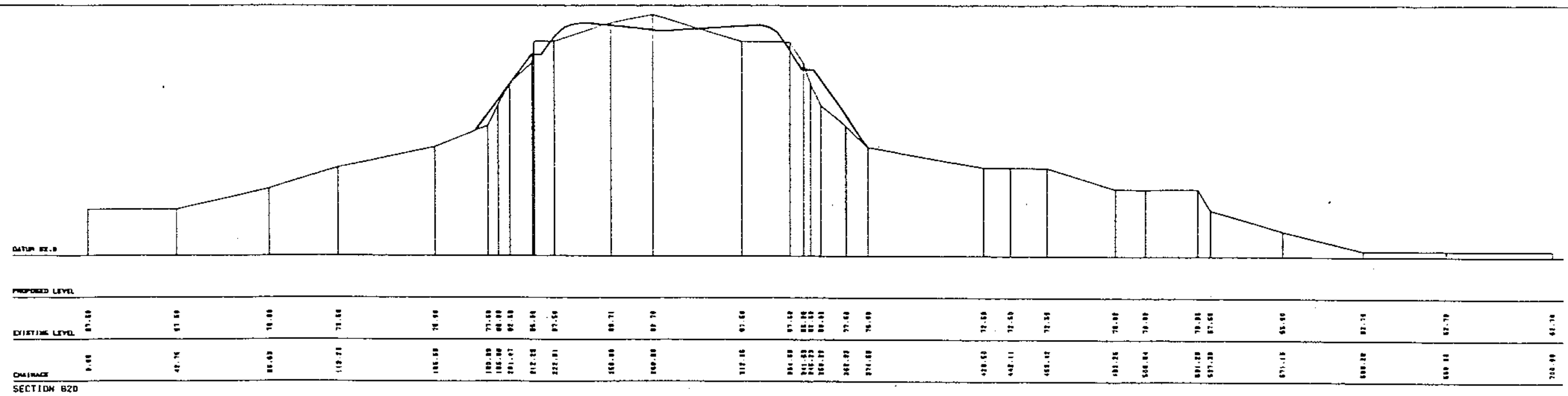

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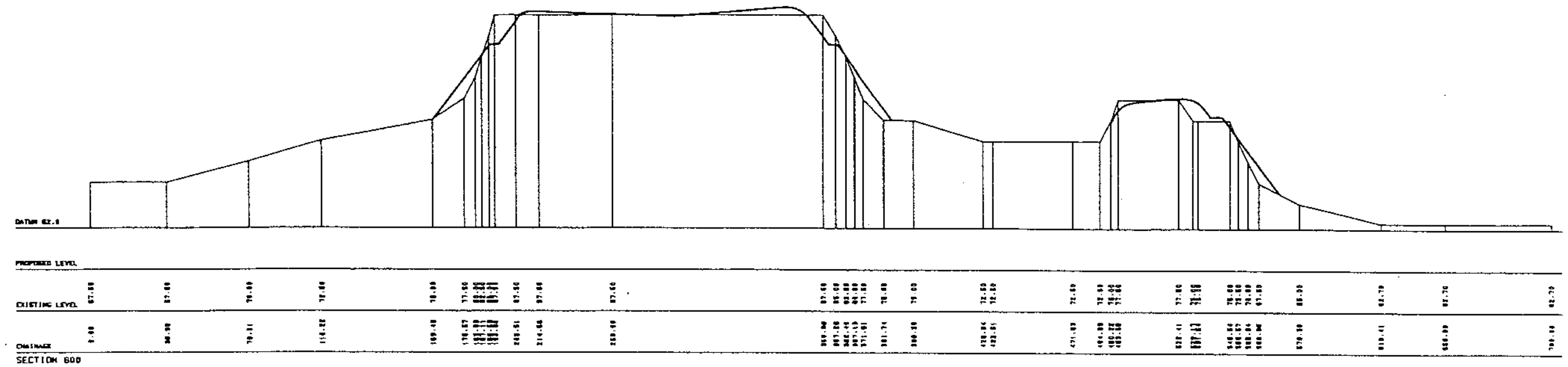

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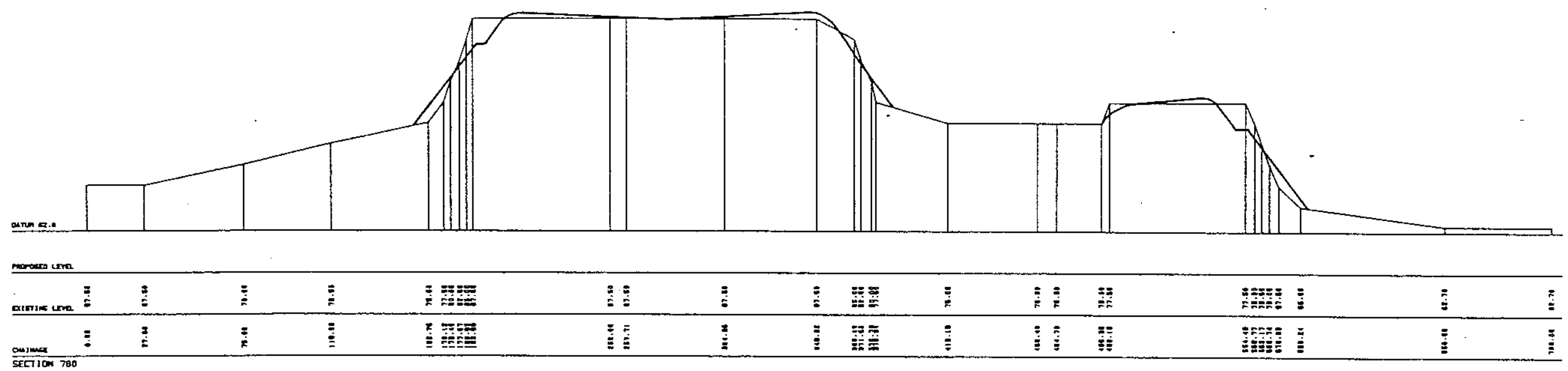

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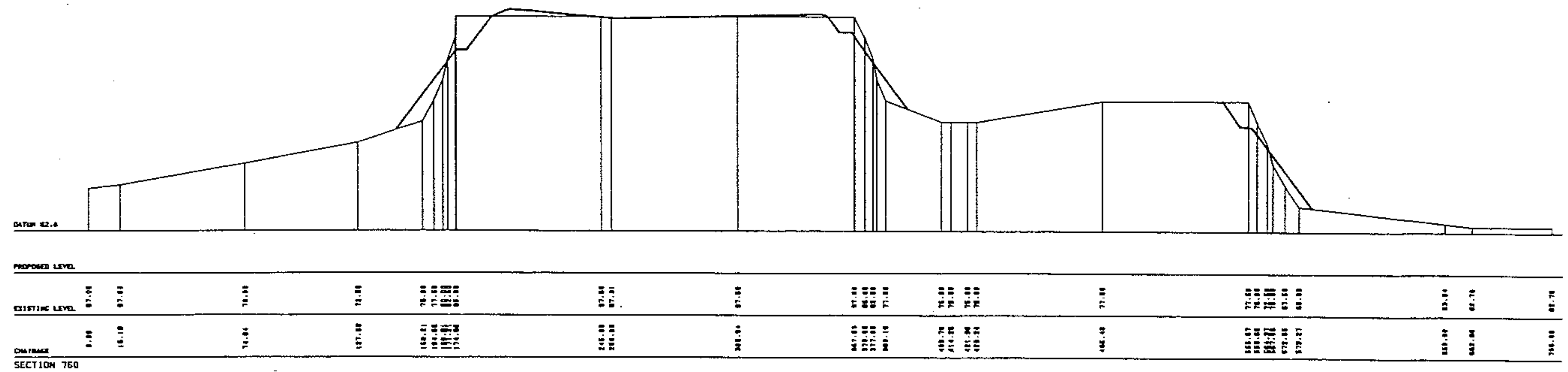

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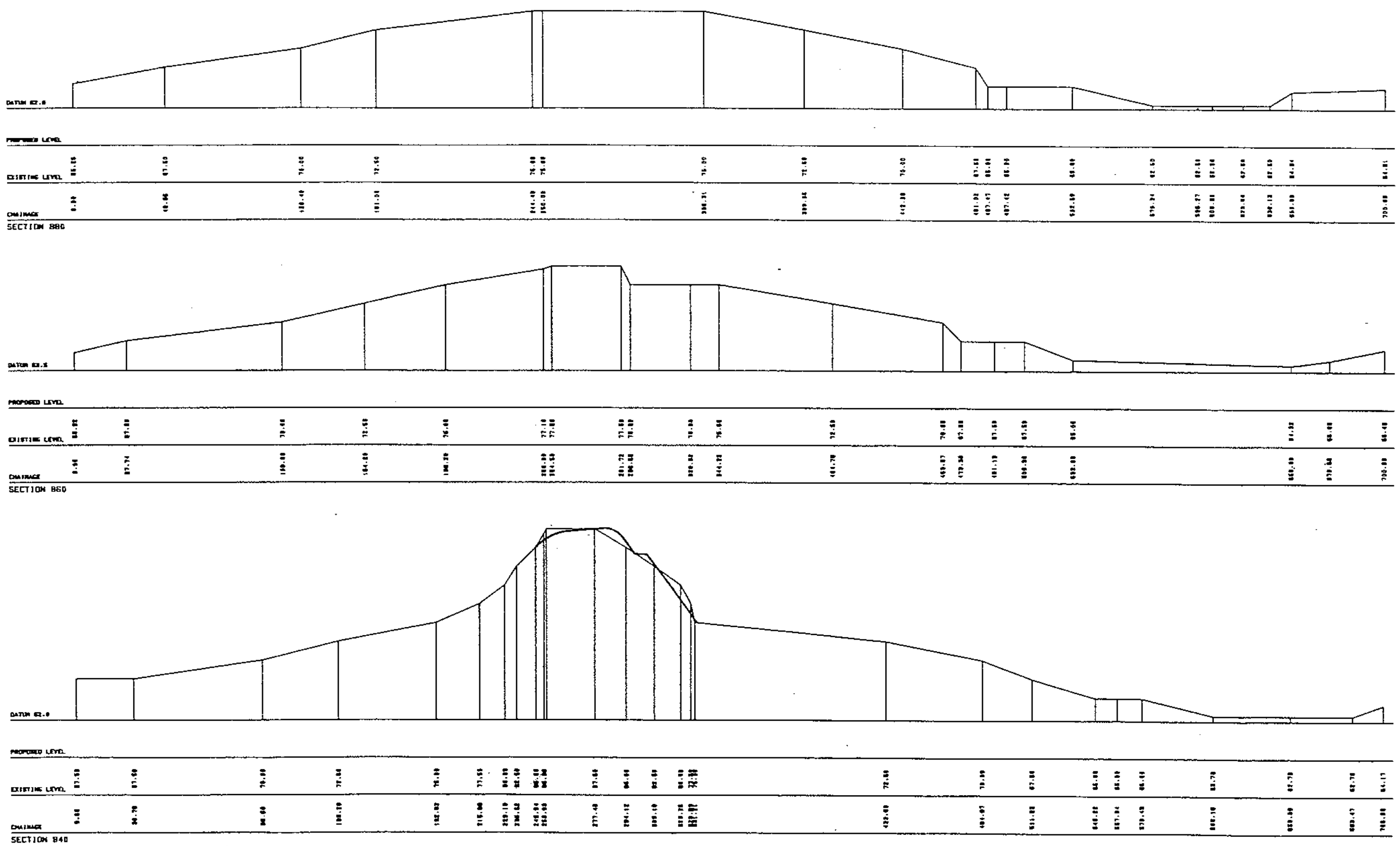

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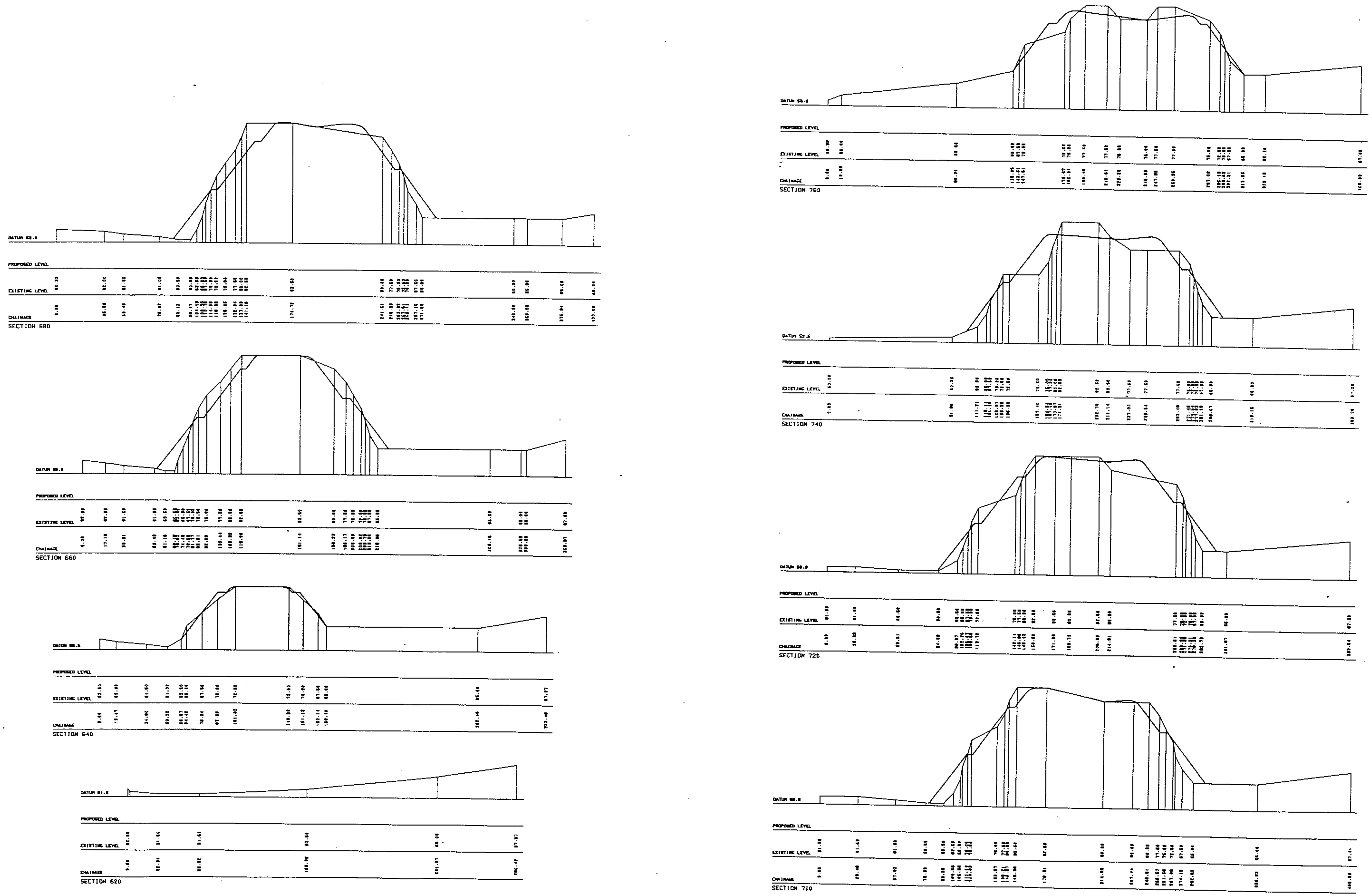

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TITLE: RUM JUNGLE REHABILITATION
INTERMEDIATE - TYPICAL SECTIONS

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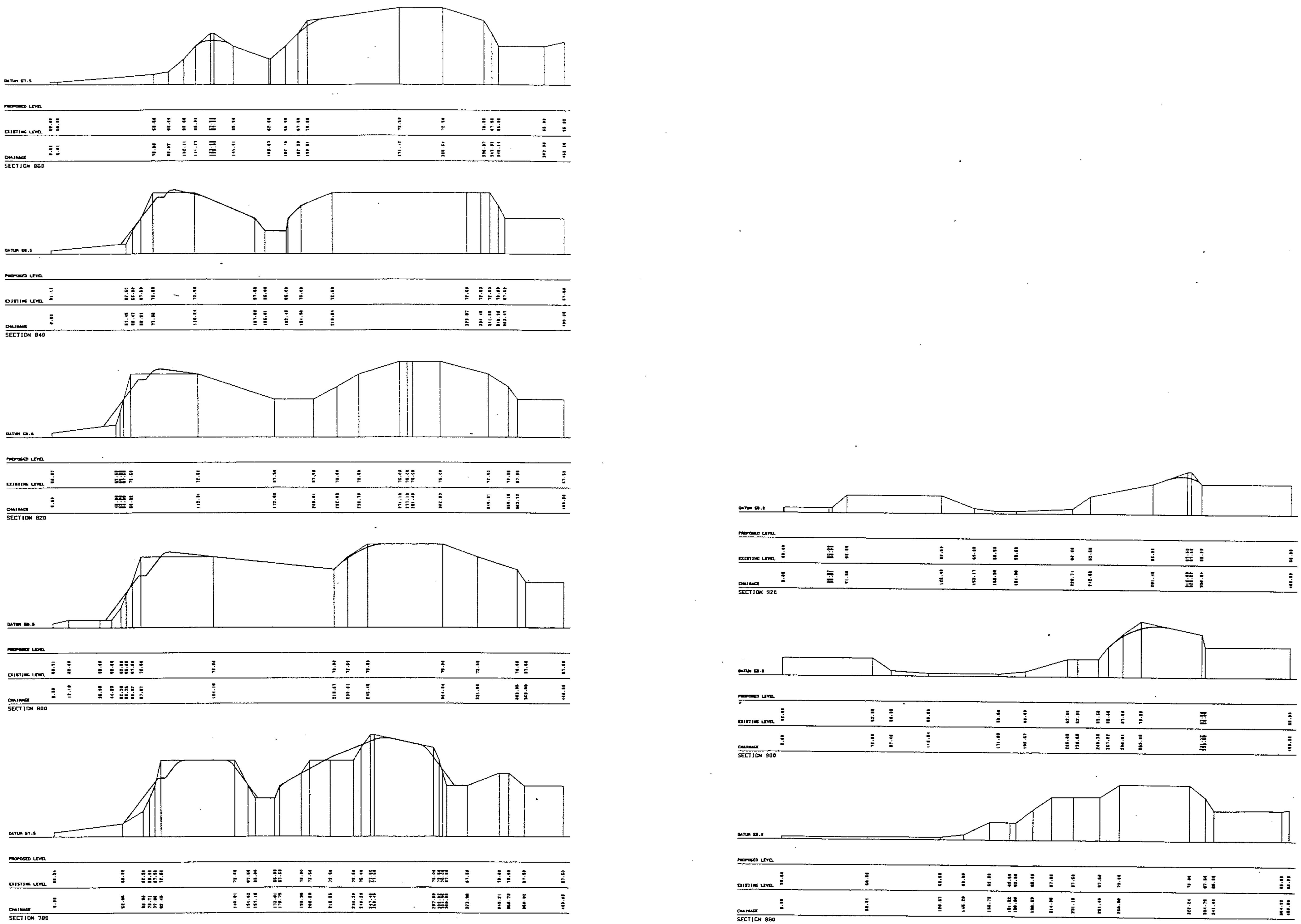

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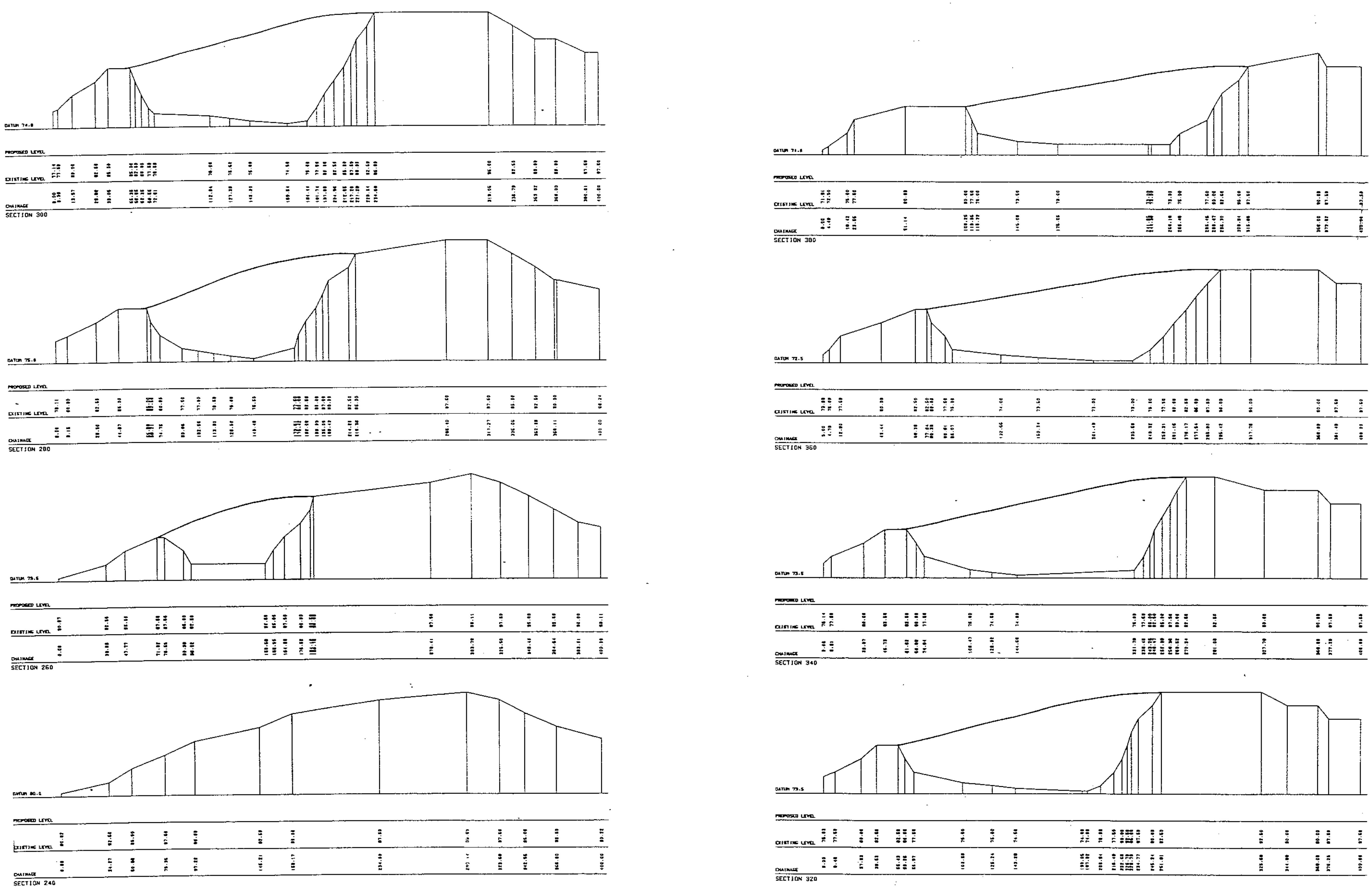

DYSON'S

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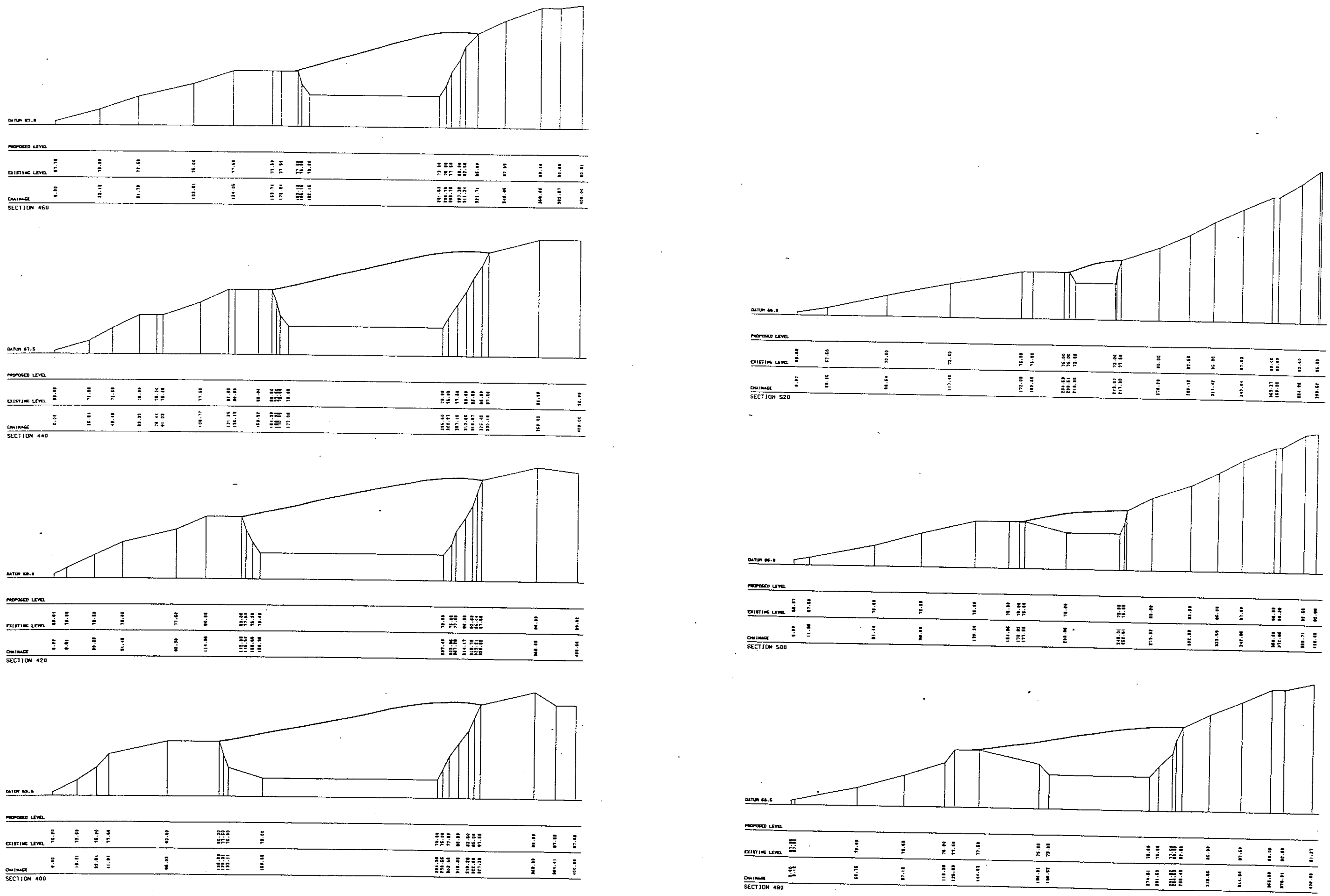

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TITLE: RUM JUNGLE REHABILITATION
DYSON'S - TYPICAL SECTIONS

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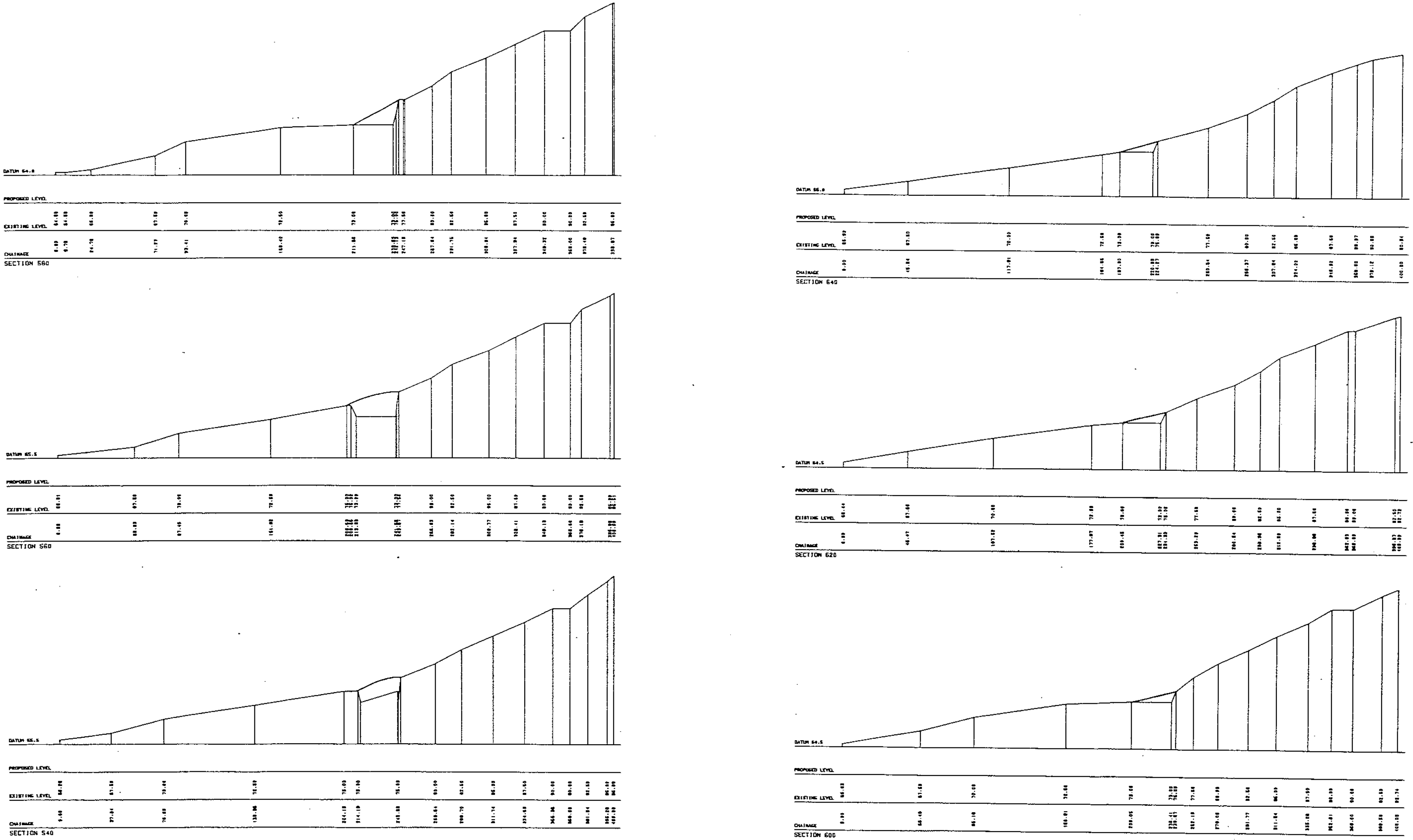

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Rad Materials Branch
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INDEXED

RUM JUNGLE REHABILITATION PROJECT

ENGINEERING REPORT
MAY 1982

FOR

THE NORTHERN TERRITORY OF AUSTRALIA

DEPARTMENT OF TRANSPORT AND WORKS

BY

Mining & Process Engineering Services
(N.T.)Pty.Ltd.
SUITE 2/3 WHITEFIELD STREET,
DARWIN.

VOLUME 3

NORTHERN TERRITORY

DEPARTMENT OF TRANSPORT AND WORKS

RUM JUNGLE REHABILITATION PROJECT

WATER TREATMENT STUDY

MAY 1982

PREPARED BY:

MINING AND PROCESS ENGINEERING

SERVICES (N.T.) PTY. LTD.

SUITE 2, 3 WHITEFIELD STREET

C O N T E N T S

CONTENTS cont.

1.0 DEFINITION OF THE PROBLEM

1.1 Generally

1.1.1 The problem addressed by this study is as follows:-

"suitably to treat by use of a conventional water treatment plant, the contaminated water contained in the Whites, Intermediate and Dysons open cut pits, for discharge into the Finniss River system and render that water remaining in the pits suitable for recreational use".

1.1.2 The pit water is acid having a pH of approximately 2.8 and contains high concentrations of heavy metals. Details of water quality are shown in the reports nominated in Section 2.1.1 and 2.1.2.

1.1.3 The "Australian Public Health Recommended Standard For Drinking Water (Australia)" has been adopted as the desired treated water quality for the Rum Jungle Project (refer Table 1).

1.2 Backfilling of Open Cuts

As part of the overall Rum Jungle Rehabilitation Project some backfilling of the open cuts will occur. Generally it is proposed that these operations shall be as follows:-

totally fill Dysons open cut with overburden	$700 \times 10^3\ m^3$
place copper heap leach material into Dysons open cut	$190 \times 10^3\ m^3$
placement of a clayey gravel into the bottom of Whites open cut to act as a plug inhibiting possible ongoing reaction which may occur between acid pit water and the existing tailings and pyritic overburden to be placed into the pit	$100 \times 10^3\ m^3$
Whites north overburden into Whites open cut	$150 \times 10^3\ m^3$
Total	$1.140 \times 10^6\ m^3$

The backfilling operation shall take place at the rate of approximately 8000m^3/day.

The three open cuts are to be connected in series with the water displaced by the backfilling operation finally flowing into the Intermediate open cut. The interconnection of the open cut forms part of the earthworks operations. Practicality dictates that water treatment should coincide with the backfilling operation.

TABLE 1

	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	
Cadmium		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

N.B. Refer to key on Next Page:

<u>KEY</u>:

** 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 page 1 & WHO International Standards for Drinking Water, 1981 (3rd editions) page 36 Table 2 (see Annexure B).

(c) Methylene Blue Active Substances

1.3 Stages of Water Treatment

The water treatment programme will take place in two stages:

Stage 1 The water displaced by the backfilling operation will be treated and pumped away from the plant for disposal.

Stage 2 The water remaining in the open cuts will be pumped from the Intermediate open cut through the treatment plant and returned to Whites open cut, from where it will flow back into the Intermediate open cut. This circulation will continue until the pH in the open cuts reaches an acceptable level.

It is possible that contaminated ground water may presently be flowing through the open cuts and that any reduction in water level created in Stage 1 may convert this through flow to a net inflow of such ground water.

Accordingly it has been allowed in the calculations below to deal with the maximum conceivable inflow or through flow of ground water which could occur during Stage 2 by providing for lime for neutralization of this water.

It has been allowed that sufficient mixing in the pits will occur such that treatment of a volume of water equal to that contained in the open cuts after backfilling will bring the pH of all water in the pits to a satisfactory level.

Lime would be added at higher rates than theoretically required to enable additon of the full calculated amount in a finite period, i.e., lime input would not assymtote to an infintisimally small rate as the pH of the feed water rose.

1.4 Capacity of the Treatment Plant

It is proposed that the capacity of the treatment plant be 10,000m^3/day, with this figure being selected because it exceeds the backfill rate and is sufficiently large to enable total treatment to be completed in a realistic time.

1.5 Volume of Water to be Treated

The volume of water requiring treatment is 5.12 x 10^6 m^3 and comprises the following:

1.5.1 The present unfilled volume of the open cuts.

Whites	2.5 x 10^6 m^3
Dysons	0.7 x 10^6 m^3
Intermediate	0.95 x 10^6 m^3
Total	4.15 x 10^6 m^3

The above figures were extract from Table 8, page 68, Report of the Working Group - Summary. April 1978 refer Appendix 1.

1.5.2 An allowance of 0.97 x 10^6 m^3 for contaminated groundwater flow through the open cut system during the treatment programme (see Section 1.7).

The evidence of the existence of the groundwater flow comes from the following reference:

Australian Mining & Smelting
8th Commonwealth Mining and Metallurgical Conference

Author: T. Barlow

(refer Chapter 9, Page 211, Uranium (see Appendix 2)).

The article outlines the history of the operations at Rum Jungle.

On Page 213 it is stated that 750 million gallons of water was pumped from Whites open cut during its 4 year life. This equates to a rate of 2335m^3/day. Hence allowance was made for an approximate 2500m^3/day of contaminated water flow through the pit system as the extreme upper limit possible.

1.5.3 It has been assumed that the water flowing through the pits is contaminated to some degree. There has been no hard evidence generated from ground water investigations to support this statement but it is believed that some contamination would result if the ground water is considered to flow between the individual pits.

The mechanism by which this would occur or level of contamination are now known. However, for the purpose of this study the possibility cannot be ruled out as the cost of reagents to neutralize any such effect is significant.

1.6 Determination of the Treatment Period for Stage 1

The duration of Stage 1 is calculated as shown below:

$$\text{Total volume of backfill} = \frac{\text{Duration in days}}{\text{Fill rate per day}}$$

$$\text{i.e. } \frac{1.14 \times 10^6 \ m^3}{8{,}000 \ m^3/\text{day}} = 142.5 \text{ working days}$$

$$\therefore \quad \text{effective days} = \frac{142.5}{0.78} = 183 \text{ days}$$

This treatment period is based on treating the water at the reduced rate of $8000m^3$/day. However, should the plant be run at its full capacity of $10,000m^3$/day the overall treatment period would be reduced with a reduction of the water level in the Intermediate open cut by approximately 2.5m.

1.7 Determination of the Treatment Period for Stage 2

The duration of Stage 2 of the water treatment programme was determined as follows:

Volume of water to be treated during Stage 2 is:

4.15×10^6 (pit volume) $-$ 1.14×10^6 (backfill) $= 3.01 \times 10^6\ m^3$

Treatment period required is:

$$\frac{2.975 \times 10^6\ m^3}{10{,}000\ m^3/day} = 301 \text{ working days}$$

To determine an effective operating year consider:

6 day week x 24 hrs per day (i.e. 52 days lost per year)

public holidays - 8 per year

downtime - say 20 days per year

$$\therefore \text{ effective year} = \frac{365 - 52 - 8 - 20}{365} \times \frac{100}{1} = 78\%$$

$\therefore$ allowing for the effective year

the total time elapsed during Stage 2 $= \dfrac{297.5}{0.78} = 386$ days

$\therefore$ Volume of ground water flow $= 386 \times 2500$

$= 0.97 \times 10^6\ m^3$

2.0 EVALUATION OF DATA COLLECTED TO DATE

2.1 Data available at commencement of Study

At the outset of the Study the information available from testwork previously carried out on the pit water comprised the following:

2.1.1 Data on the potential range of alkaline chemicals to neutralize acidity and precipitate heavy metals. The effect of this type of treatment on macro-ion concentrations being noted.

The reagents considered were lime (CaO), limestone ($CaCO_3$), sodium aluminate ($Na_2Al_2O_4$), lime - sodium carbonate and lime-sodium hydroxide.

refer to report:
"Chemical treatment of Whites pit water and the Intermediate pit water - Rum Jungle Mine".

by: The Northern Territory of Australia
Department of Transport and Works.
(see Appendix 3).

2.1.2 Chemical analysis of the water quality of Whites and Intermediate open cuts stating the heavy metal concentrations, pH and conductance. Some data is included on the effect of pH level on the precipitation of heavy metals.

refer to report:

"Water sampling and analysis for Intermediate open cut, Rum Jungle, 21 July 1981".

and

"Water sampling and field analysis for Whites open cut Rum Jungle, 8 September 1981".

both reports were produced by:

The Northern Territory of Australia,

Department of Transport and Works.

(see Appendix 4).

2.1.3 The indications from the reports mentioned above were:

(a) that slaked lime would be the most practical reagent to use for neutralization.

(b) the pH of the water would have to be raised to approximately 10 to precipitate all the relevant heavy metals the last of which is Manganese.

(c) the quality of the water varies from pit to pit and varies according to depth in the individual pits. Hence, the reagent consumption will vary during the treatment cycle.

2.2 Additional Testwork Implemented

Additional testwork was initiated by the Study Consultant through the Northern Territory of Australia - Departmnet of Transport and Works.

The data generated from these tests related to the following:

2.2.1 rate of reaction of reagents using dolamite ($MgCO_3$), limestone ($CaCO_3$) and lime (CaO).

2.2.2 settling tests using lime addition to determine the settling characteristics of the flocculated material.

2.2.3 cadmium analysis of the pit water.

Reults of the testwork to date and the procedures adopted are detailed in the report:

"Analytical results for water treatment tests requested by the Study Consultant" (refer to Appendix 5).

2.3 Evaluation of additional testwork

2.3.1 Test Results

The test results reflect a general pattern that indicated:

(a) limestone ($CaCO_3$) and dolomite ($MgCO_3$) are not sufficiently reactive to reduce the Manganese ion concentration level to that required by water quality considerations i.e. less than 0.5 mg/l.

Hence, these were not considered any further as viable reagents.

(b) the use of slaked lime proved to be successful in attaining the required treated water quality.

(c) that the reaction rates of limestone and dolomite are so slow that they are not conducive to reasonable plant design.

2.3.2 Water Treated

The water treated was from Whites open cut with the average quality being as follows:

pH	2.8	
Cu	46	mg/l
Ca	280	mg/l
Fe	82	mg/l
Mn	70	mg/l
SO_4	4760	mg/l

Whilst it is not represenative of all the water qualities to be treated, it is regarded as being typical in settling behaviour to that showing higher or lower levels of contaminants.

It should be remembered that lime concentrations required to treat the water will be directly related to the level of contaminants, e.g. higher contaminants requires higher lime consumption.

However, the settling characteristics will not vary greatly from those established in the tests, as the overall concentration of the flocs is:

(a) low in absolute forms
(b) flocs will be of similar composition
(c) heavier floc formation will result in denser settled pulp.

2.3.3 Flocculated Pulps

It was noted in the laboratory tests that the flocculated pulp was easily remobilised by minor convection currents and agitation.

2.3.4 Treated Water Quality

Tests indicate that the plant as proposed will meet the required water quality as far as heavy metal concentrations are concerned but that the level of dissolved calcium and sulphate compounds, while varying with the degree of contamination of the feed water, will exceed the nominated standards. Emission levels will be in the order of:

Ca	900	to	1000	mg/l
SO_4	1900	to	2000	mg/l
Cu	$<$ 1.0	mg/l		
Fe	$<$ 0.5	mg/l		
Mn	$<$ 1.0	mg/l		
pH	8.8	to	10	

2.3.5 Settling Rates

Preliminary settling rate data was generated with the procedures adopted and results obtained being as detailed in the report:
"Analytical results for water treatment tests by the Study Consultant" (refer to Appendix 5).

The settling rate curve for lime addition of 2.22 grams per litre as shown in figure 1 was used for preliminary sizing of the clarifier.

Note that the apparent decrease in settled density at 1250 minutes is pobably due to convection currents caused by minor laboratory temperature fluctuations.

WHITES OPEN CUT - SAMPLE TAKEN 2 METRES FROM SURFACE TREATED WITH 2.22 gms/litre LIME (CaO)

TIME VERSUS DEPTH

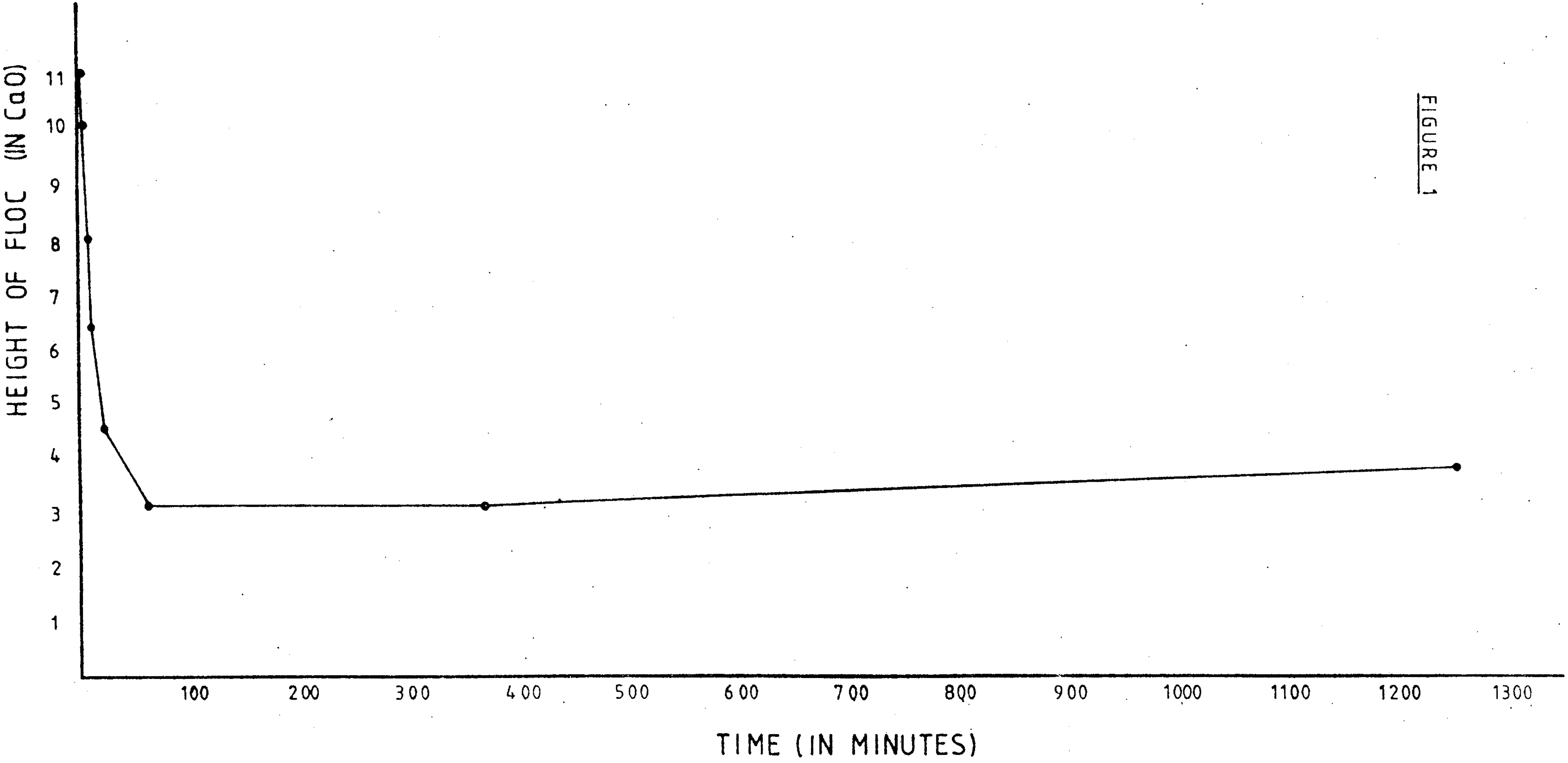


FIGURE 1

2.3.6 Lime Dosage and Consumption

Based upon the data generated typical dosage rates and total consumption have been determined as shown in Table 2.

TABLE 2

	TOTAL WATER VOLUME m^3	DOSAGE RATE kg/m^3	TOTAL QUICKLIME USED-TONNES
WHITES	2.5×10^6	3	8523
INTERMEDIATE	0.95×10^6	1.7	1835
DYSONS	0.70×10^6	1.3	1035
GROUND WATER FLOW	0.97×10^6	1.0	1102
TOTALS	5.12×10^6		12495

N.B. The quicklime supplied contains 88% available Ca0 hence the totals of lime used as shown in Table 2 have been adjusted by a factor of 0.88 to give actual tonnes used.

2.4 Additional Testwork

Additional minor testwork will be required of which some is currently being carried out. The data being collected will enable selection of the most suitable flocculant and optimum sizing of the thickener/clarifier.

The other testwork necessary is relevant to final sizing of the filter presses and will determine the operating parameters of these machines. This type of testwork is commercially available from the equipment manufacturers at moderate cost.

2.5 Testwork Generally

The test data collected to date indicates that use of conventional water treatment methods will reduce the heavy metal concentrations in the contaminated water to the acceptable level as stated in the Australian Public Health Recommended Standard.

The calcium and sulphate levels in the treated water will be higher than that stated as being acceptable hence the treated water will require dilution upon discharge from the treatment plant.

The information generated through investigation has been sufficient to enable confident process design and preliminary engineering of a plant suitable to treat the contaminated water.

3.0 PROCESS OVERVIEW

3.1 Introduction

The treatment of waste solutions of water containing small amounts of heavy metals has traditionally been handled by either ion exchange or hydroxide precipitation. Ion exchange, either on resins or using solvent extraction techniques is often used where economics are such that the project is commercially viable, and hydroxide precipitation is used where the prime objective is achieving heavy metal removal at minimum capital and operating costs.

In the case of the treatment of the Rum Jungle waste water contained in Whites, Intermediate and Dysons open cuts, there is no demonstrably economic argument for a commercial metal recovery unit. Therefore, the process to be used in the treatment of these waters is hydroxide precipitation.

3.2 Chemical Reactions

The chemical reactions involved in this process are generally written:

$$mM^{+d} + dD^{-m} \rightarrow MmDd \downarrow$$

where M is the metal cation of charge +d and D is the anion of charge (-m)

In general terms, the anion could be any of a number of ions (e.g. the sulphide ion) but for the hydroxide precipitation D = OH^- and m = 1.

The reaction becomes:

$$M^{+d} + dOH^- \rightarrow M(OH)_d \downarrow$$

The hydroxyl ion can be provided from a number of sources. However, the most common and cost effective source is from burnt and slaked lime,

$$\underset{\text{(Burnt Lime}}{CaO} + \underset{\text{Water)}}{H_2O} \longrightarrow \underset{\text{(slaked lime)}}{Ca(OH)_2}$$

The sequence in which heavy metals drop out of solution is dependent on hydroxyl ion concentration and the solubility product of the heavy metal hydroxide.

Table 3 below indicates solubility products for some of the common contaminants in the Rum Jungle water.

<u>TABLE 3</u>

Solubility Products Constants for Hydroxides in Waste Water

Ferric Iron	1.1×10^{-36}
Aluminium	1.2×10^{-32}
Cupric Copper	6.0×10^{-20}
Zinc	7.1×10^{-18}
Manganese	2.5×10^{-13}

Calculations indicate that the heavy metals in the Rum Jungle water will precipitate out in the order as shown in Table 4. There will be of course, some co-precipitation as the pH increases.

TABLE 4

Metal	Approx. pH at which Precipitation Commences/Is Complete
Ferric Iron	3.2 ⟶ 4.1
Aluminium	5.0 ⟶ 5.5
Cupric Copper	6.1 ⟶ 6.9
Zinc	7.2 ⟶ 7.5
Manganese	9.0 ⟶ 9.1

The above relationships are generally correct, but because of buffering etc., in real solutions, the results have been checked by laboratory test work, and found to be substantially correct.

Cobalt and Nickel also come out of solution in the range 6.0 to 9.0 but have not been included in the above tabulation. Arsenic is removed as a co-precipitant with iron hydroxide. It should also be noted that, during the increase in pH, some material may be deposited as insoluble sulphate.

3.3 Test Programme Results

Results of the testwork indicate that acceptable heavy metal removal will be achieved by increasing the pH of the water to be treated to a pH of 9.6. Precipitation of heavy metal ions will take place to values expressed below:

Fe	0.5 mg/l
Cu	0.1 mg/l
Mn	1.0 mg/l

Confirmatory analytical data is presently being prepared on all other metals. However, as Manganese is the last metal to precipitate, the others will be reduced to below these levels outlined in the recommended Australian Public Health Standard.

It should be noted that both the calcium and sulphate levels will be higher than desirable, the upper levels being limited by the solubility of Gypsum. These levels are expected to be approximately:

900	to	1000	mg/l calcium Ca
1900	to	2000	mg/l sulphate SO_4

It will therefore be necessary for plant effluent to be diluted before disposal if recommended calcium and sulphate levels are not to be exceeded.

3.4 Precipitated Material

The precipitated material will have a varying composition, but will contain a range of heavy metal hydroxides and sulphates, these being predominantly iron, copper and manganese. This material is only likely to re-solubilise under extremely acid conditions and, therefore, is suitable for returning as land fill.

4.0 PROCESS DESIGN CRITERIA

The process is designed for the continuous treatment of 10,000m^3 per day of polluted water from the Whites, Intermediate and Dysons Open Cuts. Composition of feed water is expected to vary depending upon depth and the particular open cut, but for Whites and Intermediate is within the range shown in Table 5. Dysons pit is somewhat less contaminated.

The plant is divided into the following sections:

(1) Neutralization Section

(2) Solids Liquid Separation Section

The plant service area provides the necessary air, water and chemicals to the main operation areas.

4.1 Plant Feed

The plant raw water feed is pumped from the polluted sources to the plant area.

Prior to discharge into the neutralizing tanks some of the raw water is diverted to be used as process water to produce slaked lime and lime slurry.

TABLE 5

TYPICAL FEED WATER COMPOSITIONS

OF RUM JUNGLE OPEN CUTS

	Intermediate		Whites	
pH	3.5		2.6	
Fe	2	mg/l	430	mg/l
Cu	60	"	55	"
Ni	14	"	14	"
Co	15	"	15	"
Zn	7	"	6	"
Mn	60	"	230	"
Al	60	"	280	"
Hg	0.05	"	0.01	"
As	0.001	"	0.4	"
Ca	200	"	400	"
Mg	400	"	900	"
Na	40	"	200	"
SO_4	3100	"	8200	"

4.2 Neutralization Tanks

Neutralization of the incoming water is effected in two continuous stirred tank reactors connected in series, with a nominal residence time of 2 to 3 minutes each. These tanks have characteristics approaching those of perfect mixers, and are overflow discharge.

Lime slurry at 5% solids by weight is metered into the first reaction vessels, with the pulp resulting overflowing to second tank at a pH of 9.0 to 9.6.

In this pH range heavy metals are precipiated according to the general equation:

$$M^{+d} + d\ OH^{-} \longrightarrow M(OH)_d \downarrow \quad \text{(see Section 3.2)}$$

Other reactions may also occur precipitating minor amounts of heavy metals as insoluble sulphates or complexes with hydrated iron oxides.

The suggested residence times allow for approximately 90% of the heavy metal hydroxides to precipitate in the neutralizing tanks. Reactions reach completion in the solids liquids separation section.

Pulp is recirculated from the thickener underflow and discharged into neutralizing tank No. 2. The recirculation rate is approximately 25% of the thickener underflow. Recirculation of the pulp assists in providing nucleation sites for floc build-up and so assist in increasing pulp densities of clarifier underflow.

4.3 Solids Liquid Separation

In this section the solid precipitants and residual lime products are separated from the liquid.
In addition, ample residence time is provided in the plant thickener/clarifier to enable the neutralization reactions to reach completion.

4.3.1 Thickener/Clarifier

Pulp from the neutralization reaction flows to the feed well of the thickener/clarifier. A synthetic flocculant is metered into the clarifier feed pipe at the overflow from No.2 neutralizing tank. The settling rate of non-flocculated pulp has been determined by test work, and adjusted on the basis of experience to a flocculated rate.

Indications from test work are that a minimum underflow density of 1.3% solids will be obtained. However, this rate may be increased to approximately 5% solids by the effects of pulp re-circulation and optimising flocculant addition.

The clarifier is therefore, to handle an overflow of 7.0m^3/min, with a varying underflow density 1.3 to 6% solids. Re-circulation rate is variable to suit particular operating conditions.

4.3.2 Sludge Filtration

Clarifier underflow is pumped to plate and frame filtration where it is filtered on a semi-continuous basis.

Due to the semi-gelatinous nature of the sludge it is unlikely to cause bogging of the clarifier, and the option exists for operating by holding sludge in clarifier during the cake discharge cycle, or operating the two filters in parallel.

The nature of the cake produced is as follows:

Cake thickness	25 mm
Cake density	1500 Kgs/m^3
Percent Moisture	50% H_2O

The material produced may be further dried by air blown down in the filter if required, and is suitable for incorporation in land fill.

4.4 Services

4.4.1 Lime Handling

Lime (CaO) is received in suitable containers and stored. Lime is drawn off at an appropriate rate and slaked with water, the reactions being:

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

The slurry is diluted and pumped at a controlled rate to No.1 neutralization tank.

4.4.2 Flocculant Mixing

Suitable polymer synthetic flocculant is received and mixed in dilute solutions of 1% solids, in the flocculant mixing tank. From this tank it is metered to the thickener/clarifier feed pipe and controlled on the basis of underflow density.

4.5 Process Control Criteria

The process control loops in this plant are quite simple.

4.5.1 pH Control of Lime Addition

The pH of the effluent from No. 2 Neutralization Tank is measured using a glass electrode or equivalent. The variation of pH from the set point is used to increase or decrease lime slurry addition.

4.5.2 Thickener Underflow Control

The pulp density of the thickener underflow is measured by a suitable density measuring unit. (ultrasonic, differential pressure cell, bubble probe or equivalent). The pulp density is is used to alter the flocculant addition and rake height, to bring the pulp density to the desired set point.

All other areas of the plant are manually controlled.

4.6 Assumptions Made

The assumptions made during preparation of this report are as follows:

4.6.1 The volume of water in the pits is as stated by others (refer Section 1.5).

4.6.2 Up to 2500m^3/day of contaminated ground water may presently flow through the pit system, and that reduction in the pit water levels may convert some or all of this to a net inflow.

4.6.3 The allowance of 1 kg/m^3 of lime will be sufficient to neutralize the contamination of the 2500m^3/day should it in fact be contaminated.

4.6.4 The 2500m^3/day of flow through the pit does not actually pass through the plant for treatment but the allowance of 1 kg/m^3 of lime, is added to the system and pumped back into the pits.

4.6.5 When Stage 2 is implemented the recirculated treated water will adequately mix with the untreated water destratifying it and obtaining the desired rise in pH.

4.6.6 Recirculation of one volume of the pit water will achieve the desired pH rise.

4.6.7 Water samples used in the test work are representative of the overall water quality in the pits.

4.6.8 Results obtained from testwork at the laboratory scale are indicative of those resulting at full treatment rate.

5.0 EVALUATION OF PILOT PLANT REQUIREMENTS

The process proposed for treatment of the contaminated water is conventional applying the use of proven concepts and equipment.

The chemistry relating to the water treatment method as used in this process is common place and widely applied in Industry, hence no doubts exist as to its validity.

The testwork carried out has been designed to produce usable data oriented towards a practicle solution of the problem. The results obtained have been consistent with those expected for water treatment of this nature.

Based upon the above statements it is concluded that there is no necessity for any pilot plant work, other than batch scale work normally performed to complete detail design and optimum sizing of equipment.

6.0 PROCESS DESCRIPTION

The water to be treated is pumped from the open cut to the plant and discharged directly into the first neutralizing tank. Transfer to the second neutralizing tank is by gravity via a transfer launder.

Both neutralizing tanks are continuously agitated to ensure intimate mixing of the reagents and raw water.

Addition of lime slurry is made to neutralizing tank No.1 to maintain the pH at approximately 10.

Flocculant addition is at No.2 neutralizing tank overflow.

As the neutralized water is leaving the second tank some 90% of the total solids precipitated are in suspension. The water is then pumped to the clarifier. It is here that the liquid/solid separation and final precipitation of dissolved solids occurs. The clarifier overflow is discharged via a launder to the clear water tank.

The clarifier underflow which is at a pulp density of approximately 1.5%, is split and pumped to both the plate and frame filter presses and No. 2 neutralizing tank. Approximately 25% of the clarifier underflow is recycled to the neutralizing section to act as a nucleation agent in formation of flocs.

The balance of the underflow is pumped through the filter presses to remove the suspended solids. The filter cakes are periodically discharged from the presses. They drop onto a conveyor and are stacked outside the building for periodic removal to landfill.

The filtrate is pumped back to the clarifier where it is eventually discharged in the overflow.

Treated water is pumped from the clearwater tank to either the borefield for injection into the ground during the dry season or directly into the Finniss River system during the wet season. Both these options have the effect of diluting the treated water.

Quick lime is supplied to the site in bulk containers having a capacity of 22 tonne. They are emptied into the dump hopper by use of a lifting frame. From the dump hopper the lime is pneumatically conveyed to the lime storage bin. Provision has been made for dust extraction on the dump hopper to minimise losses during dumping and reduce operator contact with the lime. The lime storage bin contains approximately 3 days lime supply.

The quick lime is discharged from the storage bin and transferred to the lime slaker by means of a screw conveyor. At this point water is added to the system and slaked lime is produced. This is a continuous process with the slaker producing lime slurry at approximately 12% pulp density. The grit remaining from the slaking operation is carried out of the machine by the grit elevator, dropped onto a conveyor and transported out of the building to a stack from where it is taken to landfill.

The slaked lime is pumped to the continuously agitated lime slurry tank where water is added to reduce the slurry density to 5% by weight. From here the 5% slurry is metered into No.1 neutralizing tank at a rate set by pH control.

The flocculant dosed into the system is made up in batches of 2 days supply. The tank is provided with an agitator which operates only when the batch is being mixed.

7.0 ENGINEERING DESIGN CRITERIA

7.1 The treatment plant is to be designed to treat $10{,}000m^3$ per day of raw pit water.

7.2 the pH of the raw water is to be considered as being 2.0 and contains contaminants as described in Table 5 page 23.

7.3 The plant water feed pump capacity shall be 116 l/s at 10m head. All wetted parts including the shaft shall be stainless steel 316. The feed water is pumped some 250m to the plant.

7.4 The feed water line size is 200mm diameter.

7.5 The residence time in the neutralizing tanks is 2 minutes and are to be continuously agitated with mechanical mixers.

7.6 Discharge from neutralizing tank No.1 to No.2 is by overflow launder.

7.7 The clarifier feed pump capacity shall be 140 l/s at 10m head. The pump shall be of cast iron construction. The liquid is 3.5% pulp density by weight, the solids being flocs and are pumped through a 200mm diameter line.

7.8 The clarifier is 30m diameter x 5.5m high. The clarifier is used to provide surge capacity during cake removal from the filter presses and has a recirculating load of 108.1 m^3/hour of water. Approximately 10% of the total solids removed from the raw water are precipitated in the clarifier. Discharge from the clarifier to the clear water tank is by overflow launder.

The clarifier is sized on settling data generated by the testwork.

7.9 The clear water tank has a nominal 5 minutes residence. time and is mounted on a concrete pad containing a sump.

7.10 The treated water discharge pump is sized to supply 120 l/s at 100m head and requires a 150 kW drive. Each of the 4 bores is supplied at a rate of 30 l/s with an available working pressure of 50m. The bores are to be located approximately 500m from the plant with the holes being drilled along a straight line and 500m apart. The main line size is 250mm diameter.

7.11 Due to the nature of the solids and the low pulp density at which they are to be pumped, the clarifier underflow suction line can be run along the bottom of the clarifier tank and out through the side wall.

7.12 The clarifier underflow pump capacity shall be 38 l/s at 85m head and shall be a positive displacement type pump. The line size to the presses is 100mm diameter.

7.13 20-25% of the clarifier underflow is pumped to neutralizing tank No.2 to act as neucliation agent. The line size is 50mm diameter.

7.14 The plate and frame filter presses are required to handle 109.5m^3/hour of water, and 1.4 tph of dry solids. Preliminary design requires the press to conform to the following:

cake thickness	25mm
cake pulp density	50%
frame size	1220mm x 1220mm
number of chambers	75
number of presses	2

the presses operate on a nominal 6 cake drops per day

total volume of cake per day 65m^3

7.15 The pressure filter cake discharge hoppers shall have minimum wall angles of 60°. Cake breaking chains are to be hung across the hopper throat.

7.16 The cake stacking conveyor is to be a nominal 900mm wide and is to convey the cake clear of the immediate plant area.

7.17 The plant building dimensions are 10m wide x 20m long x 8m high. The presses are mounted on a mezanine floor 5m wide x 20m long and 3.5m above ground floor level. A control room is also required on this level.

7.18 Bulk quick lime is supplied to the site in 22 tonnes capacity containers, the dimensions of which are 2.44m wide x 6.1m long and 1.45m high. The containers are to be emptied by use of a lifting frame for discharge through a tailgate.

7.19 The lime dump hopper is to have a capacity of 30 tonnes. The lime is tipped into it and immediately transferred pneumatically to the lime storage bin. A bin activator 2.4m diameter is fitted to the conical bottom of the bin.

7.20 A dust extraction system is to be provided for the dump hopper. Provision is made for a bag house with the lime dust returned to the dump hopper by a screw feeder.

7.21 The lime storage bin is to have a capacity of approximately 100 tonne i.e. 2.5 to 3.0 days supply. A bin activator 2.4m diameter is fitted to the conical bottom of the bin.

7.22 The bulk density of the quick lime is taken to be 1041 kg/m^3 and contains 88% available lime (CaO).

7.23 The lime slaker shall have a nominal capacity of 40 tonne per day. The slaked lime slurry is approximately 12% pulp density by weight. Plant feed water is used in the slaking process and supplied via a 50mm diameter line.

7.24 A grit conveyor of 450mm nominal width is provided for removal of grit from the immediate plant area. The nominal capacity is 0.14 tonne per hour.

7.25 The slaked lime is diluted to 5% pulp density in the lime slurry tank.

7.26 Lime is dosed into the system at the rate of 1.42 tonnes per hour through a 50mm diameter line.

7.27 Flocculant is dosed into the system at 1.5 mg/l of water supplied to the clarifier.

7.28 The air requirement for the plant is 30 l/s at 690 kPa.

7.29 The above information is to be used in conjunction with the following drawings:

Preliminary Schematic Flow Sheet
Drawing No. RJR-00/F-001

Piping & Instrumentation Diagram
Drawing No. RJR-00/P-001

PLANT LAYOUT
DRAWING No. RJR-00/G-001

8.0 CONTROL AND PROTECTION OF EQUIPMENT

8.1 General

8.1.1 All drives will have local start/stop stations, auto-off-manual selector switches in the control rooms, overload protection and isolators in the motor control centre (M.C.C.).

Any drive will start by:

Local Start with selector switch in manual position.

Group Start with selector switch in auto position

Local audible alarm and delay before group start

8.1.2 Any drive will be stopped by:

Local stop,

Group stop

Overload tripped due to high amps

Selector switch in off position

Isolator in off position

8.2 Lime Storage Bin 31

Condition monitoring:

Low/low and high level for indication in the control room and for control as per paragraph 8.3. Low and medium level for indication in the control room.

8.3 Bulk Lime Transfer

Low/Low level in the lime storage bin 31 will raise an alarm. The lime dump hopper 22 will then be filled with bulk lime and lime transfer will be initiated by pushbutton, starting the following drives:

Lime storage bin insertable dust collector 30

Bag house blower 26

Bag house rotary valves 28 and 29

Bag house screw conveyor 27

Lime transfer blower 24

Lime dump hopper bin actuator 23

When level in lime storage bin 31 reaches high level, lime transfer blower and lime dump hopper bin activator will stop and after a time delay, the dust collection system will stop.

8.4 Lime Storage Bin Screw Feeder 44

Manual local speed control.

8.5 Lime Slaker 33

Mechanical adjustment of water addition via torque monitoring arrangement. Measurement of water flow recording and for control as per paragraph 8.6.

8.6 Lime Slurry Tank 37

High level will stop lime storage bin - bin actuator 32 and lime storage bin screw feeder 44.
Low level will raise an alarm and stop the plant feed water pump 01.
Condition monitoring and control.
The flow of the water addition will be proportional to the water flow into the slaker, and will be controlled by a ratio controller.

8.7 Plant Feedwater Pump 01

Start by: paragraph 8.1.1
Stop by : paragraph 8.1.2, low level in lime slurry tank 37, failure of clarifier feed pump 06 or failure of treated water discharge pump 18.

Measurement of flow in feedwater line for recording and for control of flocculant addition into neutralizing tank No.2 via flocculant metering pump 42.

8.8 Neutralizing Tank No.2

Monitoring and Control.
pH level will be displayed and recorded in the control room. A pH controller will determine the amount of lime addition to neutralizing tank No.1 via the lime metering pump 39.

8.9 Clarifier Feed Pump 06

Start by: paragraph 8.1.1
Stop by : paragraph 8.1.2, failure of plant feedwater pump 01 or failure of treated water discharge pump 18. Loss of flow in clarifier feed line will raise an alarm in the control room.

8.10 Flocculant Tank 40

Low level will raise an alarm.

Flocculant metering via metering pump, volume controlled by manual adjustment following measurement of underflow pump density.

8.11 Clarifier Underflow Pump 09

Start by: 8.1.1
Stop by : 8.1.2
Loss of flow in clarifier underflow line will raise an alarm.

The density and pressure in this line will be displayed in the control room. High pressure will raise an alarm to prompt the operator to clean one of the filtrate presses.

8.12 Filtrate Pump 14

Start by: 8.1.1
Stop by : 8.1.2, failure of clarifier underflow pump

8.13 Clear Water Tank 17

Condition monitoring:

pH monitoring for indication and recording in Control Room.

8.14 Treated Water Discharge Pump 18

Start by: 8.1.1

Stop by : 8.1.2, failure of plant feedwater pump.

Loss of flow in treated water discharge line will raise an alarm.

8.15 Borefield

Condition monitoring:

Each bore will have local flow and pressure indication.

8.16 Sump Pumps

Start by high level in sump or local start.

Stop by low level in sump or local stop.

9.0 EQUIPMENT LIST

ITEM	QTY	DESCRIPTION	kW	TOTAL COST
PUMPS				
01	1	Plant feedwater pump Allis Chalmers PWO 8 x 6 x 17 special purpose pump with stainless steel wetted parts and shaft. Duty 116 l/s @ 10m.	30	17,000
06	1	Clarifier feed pump Kelly & Lewis 8MFV pump of cast iron construction. Duty 140 @ 10m.	15	3,850
20	1	Sump No. 2 pump Kelly & Lewis 3 - 4 vertical sump pump. Duty 30 l/s @ 15m.	7.5	4,050
42	1	Flocculent dosing pump. Prominent model B04017 stainless steel dosing pump. Duty 12.5 l/h.	0.25	1,500
36	1	Lime slurry pump (primary) Warman 3/2 BSC slurry pump. Duty	2.2	3,000
39	1	Mono pump metering pump Duty 9.1 l/s @ 4m.	2.2	3,500
09	1	Pretreator/clarifier underflow pump Mono CLR 211 425 RPM. Duty 38 l/s @ 85m.	55	18,100
14	1	Filtrate pump Kelly & Lewis 5 - 9 model 70. Duty 30 l/s @ 5m.	4	1,600
18	1	Treated water discharge pump Indeng VRE 6/8 pump. Duty 120 l/s @ 100m.	150	26,000
19	1	Sump No.1 pump Kelly & Lewis 3 - 4 vertical sump pump Duty 30 l/s @ 15m.	7.5	4,050

ITEM	QTY	DESCRIPTION	kW	TOTAL COST
MAJOR ITEMS OF EQUIPMENT				
25 28 29	1	Baghouse for lime dust control. Comprising 2 x DLM - 4 - 4 - 15 pyramid hoppers each with motorized rotary valves duct work associated with baghouse.	2.2	31,450 6,000
24	1	Lime transfer blower (dump hopper to storage silo) Capcity 30 TPH.	22	25,000
33	1	Wallace & Tiernan lime slaking system Capacity 40 TPD.	3	65,000
08	1	Dorr Oliver pretreater/clarifier 30m Ø supply comprises mechanism and recirculation pump.	0.37	120,000
10 11	2	Shriver plate and frame filter presses semi-automatic operation size M48-75. Capacity approx 40 TPD dry solids.	1.5	300,000
44	1	Lime transfer screw 150 Ø	1.5	6,000
MISCELLANEOUS ITEMS OF EQUIPMENT				
23	1	Bin activator 2.4m Ø - for lime dump hopper.	2.2	12,000
26	1	Baghouse blower. Chicago Size 30 SISW industrial fan complete with motor and drive. Duty 28800 m^3/hr @ 200mm	22	4,000
27	1	Baghouse transfer screw conveyor 150 Ø x 6m long.	2.2	10,000
30	1	Dalamatic DLMV9/15W insertable filter - for lime storage silo required air supply 3.9m^3/hr @ 45 kPa.		2,000
32	1	Bin activator 2.4m Ø - for lime storage silo.	2.2	12,000
35	1	Grit removal conveyor 450mm inside x 15m long.	2.2	12,000
38	1	VLBT-10 chemineer mixer - for 5% lime slurry holding tank.	0.75	3,100
03 05	2	2HTD-55 chemineer mixers - for neutralizing tanks.	8	11,450
41	1	VLBT-10 chemineer mixer - for dosing tank.	0.75	3,100

ITEM	QTY	DESCRIPTION	kW	TOTAL COST
15	1	Filter cake stacking conveyor 900mm inside x 30m long. Capacity 6 tonne/cake drop @ 2 drops every 4 hours.	5.5	25,000
21	1	Atlas copco automan A12 compressor 30 1/s @ 690 kPa.	15	5,475
		TOTAL	kW 365	$736,225

ITEM	QTY	DESCRIPTION
STEELWORK - HOPPER, TANKS, BINS AND CHUTES		
22	1	Lime dump hopper. 4m Ø x 4.5m high conical bottom ex 6mm plate. Capacity: approx 30 tonnes.
31	1	Lime storage silo 4m Ø x 10m high conical bottom ex 6mm plate. Capacity: approx. 100 tonnes.
34	1	Lime slurry pump hopper, 1.2M Ø x 1.5m high conical bottom ex 6mm plate. Capacity: approx. $0.75m^3$.
37	1	5% lime slurry tank 2m Ø x 2m high flat bottom ex 6mm plate. Capacity: approx. $6.25m^3$.
02 04	2	Neutralizing tanks 2.5m Ø x 3.5m high flat bottom ex 6mm plate. Capacity: approx. $14.7m^3$.
07	1	Pretreator/clarifier tank. 30m Ø x 5m high flat bottom ex 6mm plate complete with launder.
16	1	Pressure filter filtrate hopper 1.8m Ø x 2m high conical bottom ex 6mm plate. Capacity: approx. $2m^3$
12 13	2	Pressure filter cake discharge hopper. Opening size 1.53m inside x 6.0m long, outlet size 0.9m inside x 6.0m long ex 6mm plate.
17	1	Clear water tank. 4m Ø x 3m high flat bottom ex 6mm plate. Capacity: approx. $38m^3$.
40	1	Flocculent tank 1m Ø x 1.3m high flat bottom ex 6mm plate. Capacity: approx $1m^3$.

10.0 CAPITAL COST ESTIMATE

The estimated capital costs for the water treatment plant are as follows:

Site Preparation

Clear level and compact the site			\$ 10,000

Earthworks

Summary of quantities:

preparation of pads	$950m^3$	\$ 8,603	
preparation of ramps	$1400m^3$	\$ 12,600	
blasting	$15m^3$	\$ 2,250	
bituminising around clarifier	$341m^2$	\$ 2,728	
	Total		\$ 26,181

Concrete

(borefield excluded)

these quantities were taken from preliminary layout drawings.

total quantity	$117m^3$	\$ 46,618

All up rate including formwork, underlay, reinforcing steel, mesh and finishing average \$415.50/m^3.

Mechanical Equipment

This includes the supply of mechanical and process equipment as itemised on the equipment list except \$26,000 for the bore pump and motor. (see Section 9 for itemised costing). All costs are ex works.

Mechanical steelwork is not included in this Cost.

Mechanical Equipment	\$ 710,225

Steelwork

All costs include erection:

Building steel	29.4 tonne	\$ 76,930	
Lime dump hopper, storage bin and container tipper	25 tonne	\$ 75,814	
Tanks and hoppers	8.4 tonne	\$ 31,323	
Pretreator/clarifier	67.3 tonne	\$ 125,780	
Chutes and miscellaneous mechanical steelwork	6.25 tonne	\$ 25,705	
	Total		\$ 335,552
Cladding $600m^2$ (placed)			\$ 7,800

Mechanical Installation

Includes placement and full assembly of all mechanical equipment and steelwork	\$ 51,000

Transport - Mechanical Equipment

allowance for 90 tonne		$ 21,000

Piping

(Borefield piping excluded)

Labour	$ 20,400	
Materials	$ 16,500	
Transport 85 tonne	$ 3,740	
Plant	$ 2,200	
Excavation	$ 2,640	
Fill	$ 210	
Concrete	$ 1,310	
Total		$ 47,000

Electrical & Instrumentation

(Borefield electrics excluded)

All electrical works, including supply and installation of 750 kVa station transformer, motor control centre, control panel, main marshalling cubicle, PLC controller, lighting, earthing and instrumentation — $ 199,000

Borefield Delivery Pipeline

Piping	$ 167,000	
Pump and Motor	$ 26,000	
Concrete	$ 2,000	
Electrics	$ 6,000	
Total		$ 201,000

Total Direct Cost	$ 1,655,376
10% Contingency	$ 165,538
	$ 1,820,914
Detailed Design & Procurement	$ 190,000
TOTAL PROJECT COSTS	$ 2,010,914
say	$ 2,011,000

11.0 TREATMENT PLANT OPERATING COSTS

Item	Cost Per Week	
Spare parts	$ 600	
Maintenance (15hr/wk x $30/hr)	$ 450	
Power Supply		
365 kw total power		
320 kw continuous demand		
rate 10 cents per kw hour	$ 4,608	
Machinery allowance (hire)	$ 100	
Labour	$ 6,338	
This figure is arrived at on the basis of continually requiring 2 operators around the clock 6 days per week i.e. an all up cost of $22/hr at single time.		
Flocculant		
Consumption 30 kg/day at $3.10/kg		
flocculant cost	$ 558	
Treatment cost per week (excluding lime)	$12,654	
Total cost for 81 week treatment period.		$1,025,000
Lime Consumption		
Total 12495 tonne at $200/tonne over a total of 81 weeks		
Average cost per week	$30,852	
Total cost for 81 week treatment period	$2,499,000	
Hence		
Total all up operating cost for total 81 week period		$3,524,000

12.0 OPERATIONAL SERVICES REQUIRED

The services listed below are required for operating of the plant but no costs have been allocated for them in the Treatment Plant estimates.

The Treatment Plant has been costed on the basis that the services needed have been provided for in the earhtowrks programme.

12.1 Labour

A total of six men will be needed to operate in shifts. It is envisaged that they will come from Darwin having their own accommodation or they could be relocated at Rum Jungle.

12.2 Power

Electricity Commission power is available at Bachelor and a line could be run out to the site, a distance of some 6 km, to supply the water treatment plant requirements. Preliminary indications from the Electricity Commission are that the cost would be in the order of $118,000 and the line would take approximately 6 months to complete.

In addition the tarrif rate evoked for commercial consumption would be approximately 16¢/kW hour which is higher than local diesel generated power.

12.3 Accommodation and Messing

Accommodation and messing will be available at Rum Jungle should the need arise.

12.4 Site Facilities

The following facilities are required on site and will be provided as previously mentioned:

Site office

Ablution block

Fresh water supply

12.5 Backfilling Operations

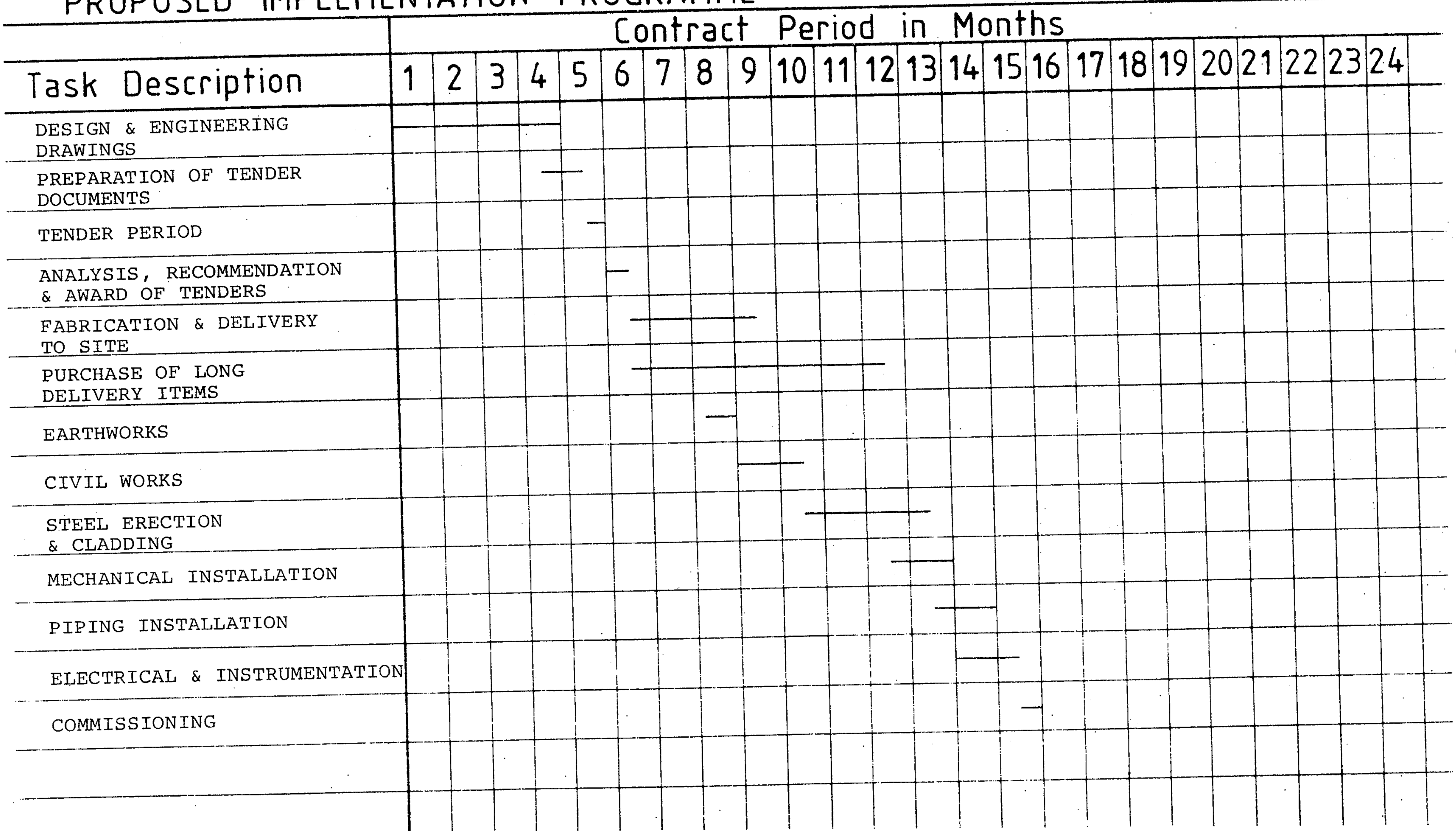
As part of routine plant operations a front end loader and operator will be required to remove the grit and filter cake from the stockpile, for backfilling to the borrow pits. The volume to be shifted is approximately $86m^3$ per day. Depending upon the size of machine available this operation is estimated to occupy 3 hours per day.

In general it has been assumed that any mobile equipment required would be obtained under the earthworks programme.

13.0 IMPLEMENTATION OF STUDY

It is estimated that a 15 month period would be required to implement the results of the Study. This covers tasks commencing from the design stage through to commissioning. For a breakdown of the tasks involved and their scheduling refer to the Proposed Implementation Programme following.

RUM JUNGLE REHABILITATION PROJECT
WATER TREATMENT PLANT
PROPOSED IMPLEMENTATION PROGRAMME



14.0 DISPOSAL OF TREATED WATER

14.1 Underground Disposal

It is proposed to dispose of the treated plant water by pumping it via a borefield into the underground aquifer system.

The area chosen for location of the bores is in a region of transmissive dolomite approximately 500m south/west of Whites open cut.

There will be four production bores in on line service, each having a capacity of 30 litre/sec. One standby bore will be provided to enable rotation of production bores for periodic backflushing.

The injection of the treated water into the underground system has benefits for the following reasons:

14.1.1 There is evidence of groundwater moving through Whites open cut and of caveneous dolomites adjacent and under the pits. Mining records have recorded water flows at various times and sink holes have been reported. The geology of the area indicates Coomalie Dolomite in the area.

14.1.2 If groundwater has been moving through the pit it is reasonable to assume that the groundwater plume around Whites open cut is already contaminated with Sulphates and possibly other heavy metals. Without any groundwater records available this is only an assumption.

14.1.3 Injection of treatment water into the ground water system would increase the Calcium level by approximately 1000mg/litre. The Sulphates in the groundwater plume around the pit would be in the same order as the treated water and no additional heavy metal contamination would occur, since they will have already been removed.

14.1.4 Calcium and Sulphates should precipitate as Gypsum ($CaSO_4$) in the underground rock formations and not produce any detrimental contamination of the groundwater during the 18 months of operation.

14.1.5 The location for water injection has been selected at a junction of two aquifers in an attempt to achieve wide dispension of the treated water.

14.2 Alternative Disposal

An alternative to the above is to dilute the plant water with potentially clean bore water to be obtained from an aquifer approximately 2km north of Whites open cut. The increased cost of pipework to this location and the available flow from the source are unknown at this stage. However, the Northern Territory Water Division advise that a significant volume should be available which will permit a dilution factor far greater than 10:1 which exceeds the interim water quality standards.

Dilution would occur by mixing the two prior to disposal into the East Finniss River system.

The use of groundwater during the dry season eliminates the need for expensive holding ponds if treatment of the pit was to continue all year round.

Even when diluting the water and pumping it into the river the possibility still exists that some precipitation may occur which is less acceptable from asthetic terms.

During 8 months of each year the level of calcium and sulphates is considered to be too high for direct release into the river system.

During the wet season all water will be diluted with surface run off and be released into the river system. The summary produced by the Working Group in April 1978 indicates that 39 x 10^6 m^3 of water is available from the East Finniss and Finniss River.

The Hydrological Section of the Northern Territory Water Divison advise that 25 x 10^6 m^3 of water/wet season is more applicable.

Using the value of 25 x 10^6 m^3 a 10:1 dilution can be achieved with the permissable levels in the Rum Jungle Intrim Water Quality Standards, refer Volume 1 Engineering Report May 1982, indicating that the intrim release standard is a 3:1 dilution with only a 5:1 dilution required to achieve final rehabilitation standards.

To monitor the water flow available for dilution gauging stations have been set up around the site. Readings provided by the stations would enable calculation of the permissable volume of water for release to dilution. The balance of water not discharged into the river system, or in the case of a totally dry wet season, the total volume of treated water, would be pumped to the borefield for injection into the ground.

Since the potential flow rates of the underground aquifers are not known and there is a need for low sulphate and calcium levels in the river water to avoid visual pollution from precipitation of salts, the injection of water close to Whites open cut is the favoured option at this stage.

15.0 WATER MANAGEMENT

As the object of the water treatment plant is to produce water suitable for discharge to the environment, the following notes provide a description of how this would be achieved in the course of other complementary operations during the Rum Jungle clean up.

15.1 Recycling of Treated Water

At some time in the treatment programme other operations may dictate re-circulation of treated water back to the originating open cut. Whilst this may seem contradictory with previous comments regarding the in situ treatment of polluted water, this paradox is explained as follows:

(a) The dilution effect for the time of operation is small e.g.

30 days operation @ 10,000 m^3/day
Effect on Whites open cut = 1.5% dilution

this is far less than the range of compositions expected to be handled in the water treatment plant from various

(b) In operating in this manner, the heavy metals are being removed from the pit, and not being precipitated at the bottom of the pit causing potential dirty overflows.

(c) Lime is being used in the most effective manner.

(d) Stratification and re-circulation problems can be avoided by careful siting of inlet and treated water discharge points in the pit.

It should be kept in mind that in situ treatment was rejected on the basis of:

problems of lime mixing (not to be confused with mere de-stratification).

problems associated with mobilisation of precipiated hydroxides.

potential for excess lime consumption.

and not the fact that the heavy metal content of the water would be reduced with time.

15.2 In Situ Water Treatment

During the laboratory testwork and detailed investigations of the controlled water treatment plant the main concern was the potential risk of the treatment plant failing to achieve the desired results within the next frame of the works.

A substantial part of the overall rehabilitation strategy is the use of Whites open cut as a dump for various overburden heaps.

The reliability of the water treatment plant becomes a big factor in the overall projects success.

During investigations no evidence of successful large scale water treatment using in situ lime dispersion was found. Where destratification was used, it had been generally used for removal of algae blooms for domestic water quality improvements, not for heavy metal precipitation.

Some preliminary design was carried out on the concept put forward by the Department of Housing and Construction when reviewing strategy estimates.

The compressed air needed for infusion at 100 metres below the surface indicated compressor blowers in the order of 400 kW each, to achieve destratification. This is significantly less agitation than that required to effectively disperse lime. Adequate mixing required huge amounts of power.

The rubber curtain concept would be very difficult to apply, as it is required to maintain the curtain in a stable vertical position due to unequal pressure being applied on each side of the curtain under dynamic flow conditions. In addition, it would suffer from re-mobilising of the settled flocs when backfilling commenced.

The contact of water to lime is one of the prime reasons for apprehension regarding the in situ system. The effective use of the lime demands adequate mixing and the general pit mixing method would not seem anywhere near the requirements found necessary in the laboratory work carried out.

Tests were carried out on the heavy metal sludge removed from the water samples.

It was found that very slight liquor turbity and temperature change were sufficient to break up the sludge and redistribute it through the liquor.

It is intended to backfill Whites during the same period of water treatment.

The water disturbance and associated currents would create a far worse effect and it may be concluded that the discharge water would still contain the heavy metals as suspended hydroxide precipitates.

The cost of lime is significant and it is imperative to achieve maximum chemical efficiency from its addition. The controlled treatment plant permits better use of lime and recirculation of the thickener underflow until the reaction has been completed.

For the reasons above the in situ plant is not recommended and any detailed study of an in situ plant would not be productive.

It is recommended that the East Finniss River be reconnected to Whites open cut for annual flushing and the connection between Whites and Intermediate remain as a permanent connection,

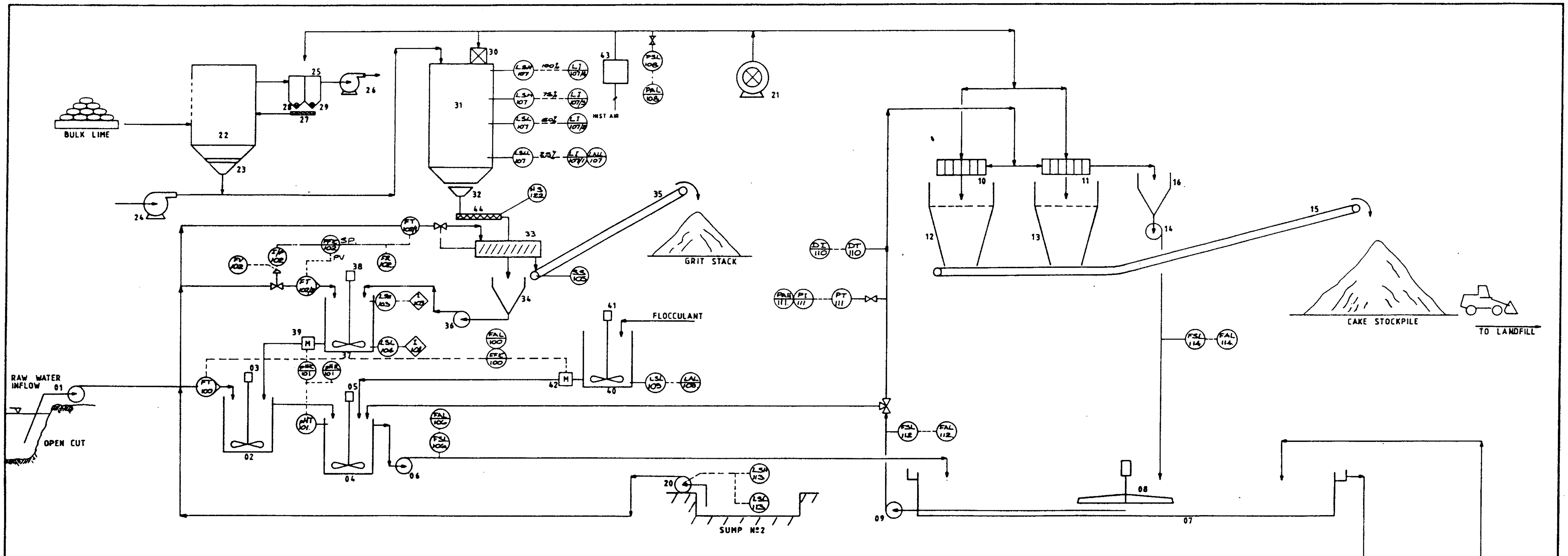
The remaining total volume of Whites and Intermediate will be 3.35 x 10^6 m^3. The annual water inflow of 25 x 10^6 m^3 will provide a significant flushing action. The incoming water should be introduced at a low level to aid destratification of the pits.

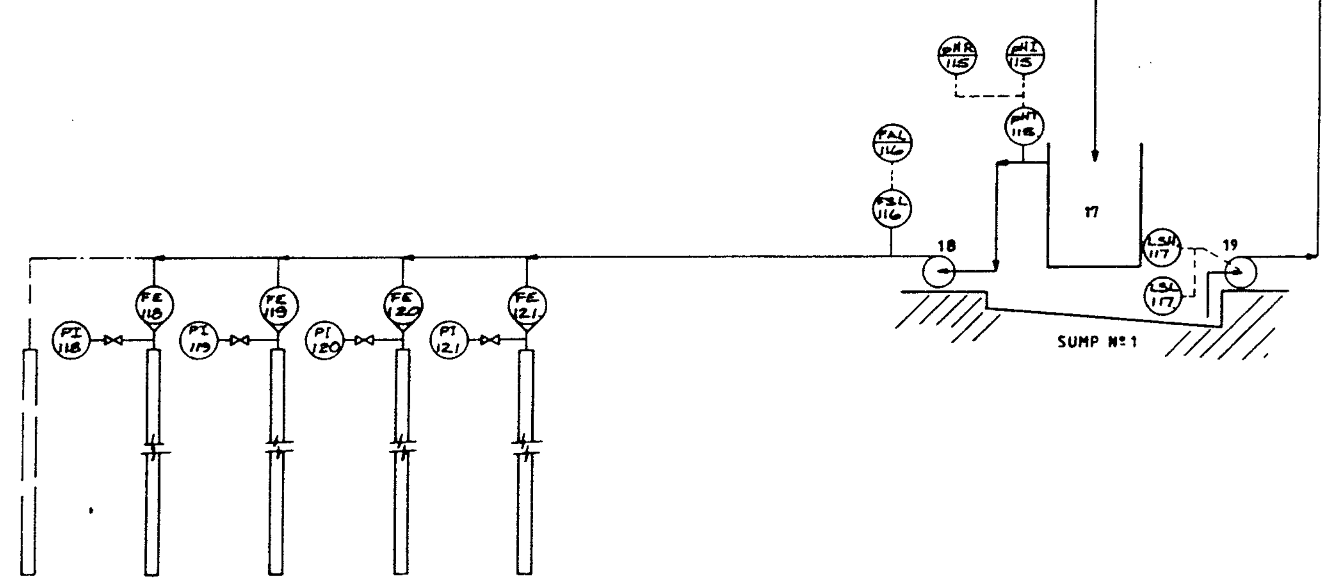
The reasons for the above recommendations are:

Sources of the acid are not really known e.g. from the walls or overburden.

We are aware that the action of the abovementioned sources may reduce the pH but it will be a slow process and annual flushing should keep the pH at a neutral level.

The analysis of pit water at various depths as carried out by the Northern Territory Water Division East Point Laboratory indicates that the level of radioeuclide contamination is well below that specified in the Rum Jungle Water Quality Standard refer Standards Engineering Report Volum 1 1982. Therefore, the tailings in the bottom of the pit will not effect the long term water quality standard during the wet season flushing.





44	LIME STORAGE BIN SCREW FEEDER	1·5
43	INSTRUMENT AIR DRIER	
42	FLOCCULANT METERING. PUMP	0.25
41	FLOCCULANT TANK AGITATOR	0·37.
40	FLOCCULANT TANK	
39	LIME METERING PUMP	2.2.
38	LIME SLURRY TANK AGITATOR	0·75.
37	LIME SLURRY TANK.	
36	LIME SLURRY PUMP	2.2.
35	GRIT CONVEYOR	2.2
34	LIME SLURRY PUMP HOPPER	
33	LIME SLAKER	3
32	LIME STORAGE BIN - BIN ACTIVATOR	2.2
31	LIME STORAGE BIN	
30	LIME STORAGE BIN - INSERTABLE DUST COLLECTOR	
29	BAG HOUSE ROTARY VALVE Nº 2	1·1
28	BAG HOUSE ROTARY VALVE Nº 1	1·1
27	BAG HOUSE SCREW CONVEYOR	2·2
26	BAG HOUSE BLOWER	22
25	BAG HOUSE	
24	LIME TRANSFER BLOWER	22
23	LIME DUMP HOPPER BIN ACTIVATOR	2·2
22	LIME DUMP HOPPER	
21	PLANT AIR COMPRESSOR	15
20	SUMP Nº2 PUMP	7·5
19	SUMP Nº1 PUMP	7·5
18	TREATED WATER DISCHARGE PUMP	150
17	CLEAR WATER TANK	
16	FILTRATE HOPPER	
15	CAKE STACKING CONVEYOR	5·5
14	FILTRATE PUMP	4
13	FILTRATE PRESS Nº2 - CAKE DISCHARGE HOPPER	
12	FILTRATE PRESS Nº1 - CAKE DISCHARGE HOPPER	
11	FILTRATE PRESS Nº2	0·75
10	FILTRATE PRESS Nº1	0·75
09	CLARIFIER UNDERFLOW PUMP	55
08	CLARIPIER RAKE	0·37
07	THKKENER / CLARIFIER	
06	CLARIFIER FEED PUMP	15
05	NEUTRALIZING TANK Nº2 AGITATOR	4.
04	NEUTRALIZING TANK Nº2.	
03	NEUTRALIZING TANK Nº1 AGITATOR	4.
02	NEUTRALIZING TANK Nº1	
01	PLANT FEEDWATER PUMP	30
ITEM Nº	DESCRIPTION	kW RATING

EQUIPMENT LIST

No.	BY	DATE	REFERENCE DRAWINGS

MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

2/3 WHITEFIELD ST DARWIN

No.	BY	DATE	REVISION	APPROV

	date	sign.
CLIENT APPR.		
PROJECT APPR.		
DESIGN APPR.	18/5/82	
CHECKED	18·5·82	
DRAWN	14·5·82	

PLANT NORTH U.O.N

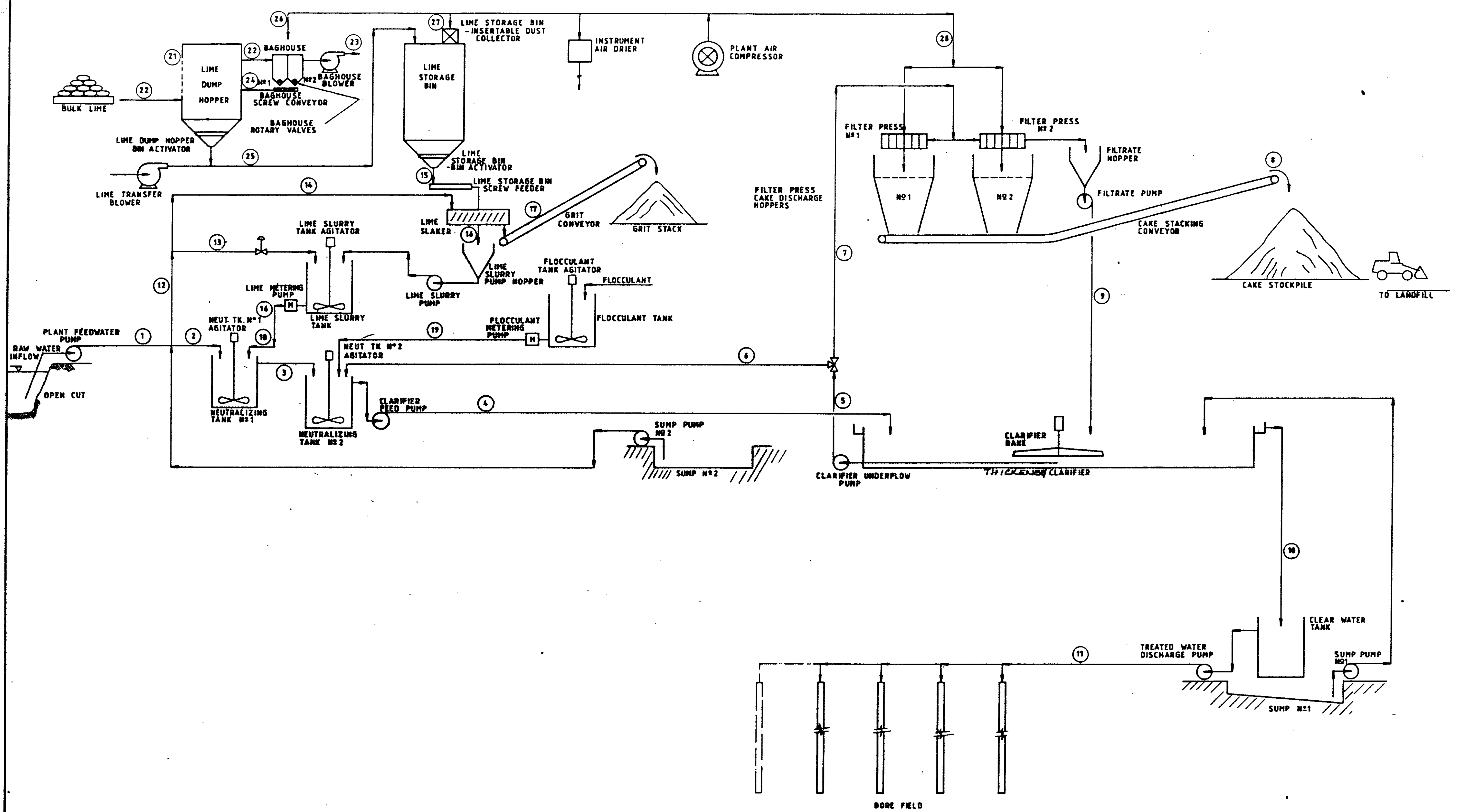
CLIENT THE NORTHERN TERRITORY OF AUSTRALIA DEPARTMENT OF TRANSPORT & WORKS

SIZE B1 SCALE N.T.S.

TITLE RUM JUNGLE REHABILITATION PROJECT WATER TREATMENT PLANT PIPING & INSTUMENTATION DIAGRAM

REV. No.

DRAWING No RJR-00/P-001



FLOWLINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Av SOLIDS FLOW tph			1·253	1·6067	1·7684	0·3537	1·4147	1·4147							1·0	1·253	0·068	1·253		30		5		5	30			
Av LIQUIDS FLOW m³/hr	420	396·393	420	447·2762	136·7909	27·276	109·5147	1·4147	108·10	418·6273	418·7890	23·0070	15·036	0·7710		0·7710		23·0070			20·0×10³		20·0×10³					
Av TOTAL FLOW t.p.h.		420	421·253	448·9249	138·5595	27·63	110·9294	2·8294	108·10	418·6273	418·7890	23·0070	15·036	0·7710	1·0	10·0240	0·068	25·06	0·042							0·0053	0·0046	0·0804
PEAK TOTAL FLOW t.p.h.							140	5·6588		418·6273	418·7890	47·6140	30·072	17·5420	2·0		0·136	50·0	0·084	50		8		8	50			
PEAK FLOW TIME hr/day							6-8	.24		24	24	24	24	24	24	24	24	24	24	2		2		2	2			
PRESSURE kPa	98			98	834				50		981															620	45	40
pH	2·8	2·8								8·5 - 9·0	8·0 - 8·5					>10		>10	APPROX 7									

No. BY DATE REFERENCE DRAWINGS

MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

2/3 WHITEFIELD ST, DARWIN

No. BY DATE REVISION APPROV.

CLIENT APPR.
PROJECT APPR.
DESIGN APPR. 18/5/82
CHECKED 18-5-82.
DRAWN 14-5-82

PLANT NORTH U.O.N.

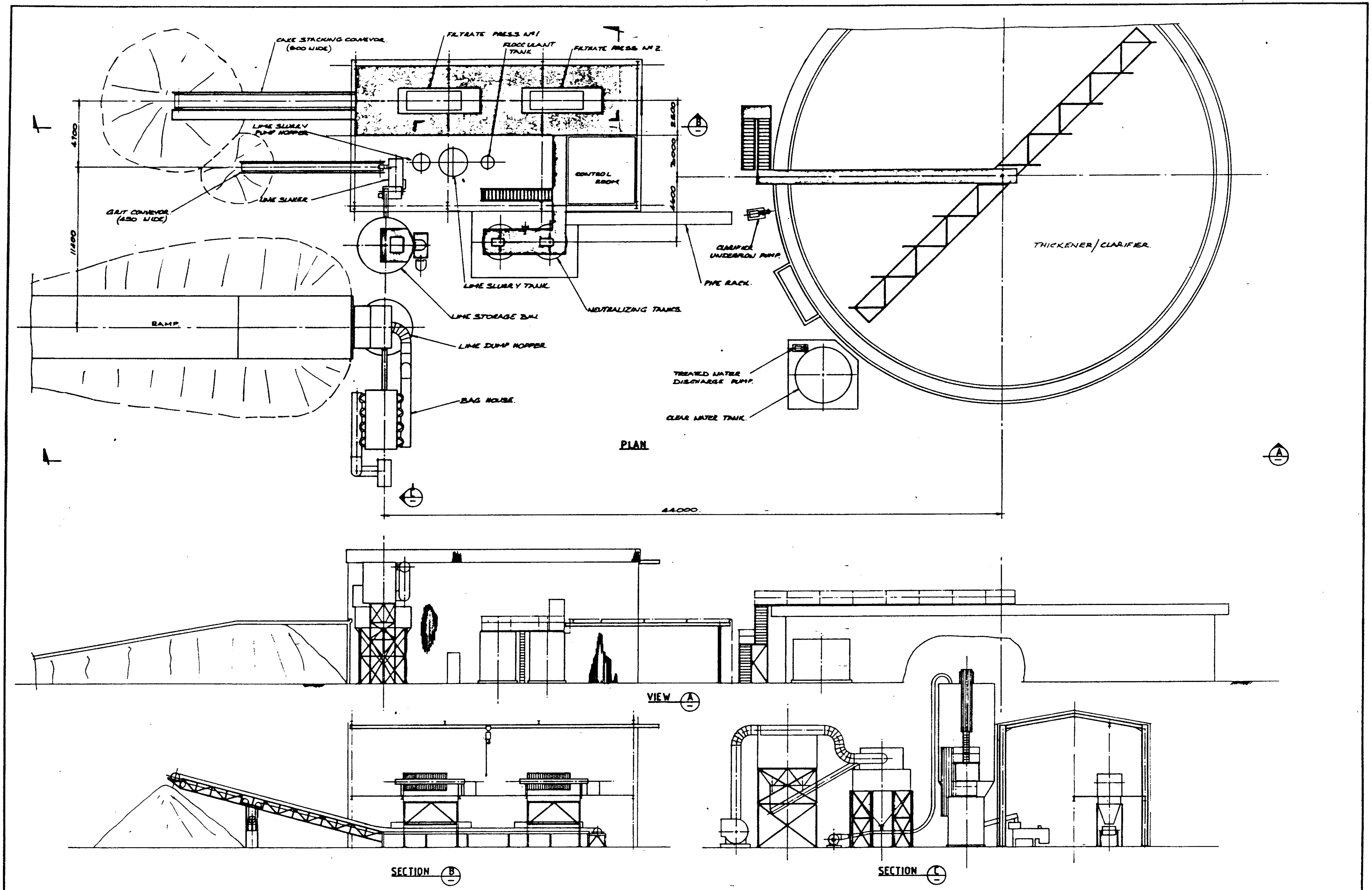
CLIENT THE NORTHERN TERRITORY OF AUSTRALIA DEPARTMENT OF TRANSPORT & WORKS

TITLE RUM JUNGLE REHABILITATION PROJECT WATER TREATMENT PLANT PRELIMINARY SCHEMATIC FLOW SHEET

SIZE B1 SCALE N.T.S.

REV. No.

DRAWING No. RJR-00/F-001



No	BY	DATE	REFERENCE DRAWINGS

MINING & PROCESS ENGINEERING SERVICES (N.T.) PTY. LTD.

2/3 WHITEFIELD ST. DARWIN

No.	BY	DATE	REVISION	APPROV.

	date	sign.
CLIENT APPR.		
PROJECT APPR.		
DESIGN APPR.	19-5-82	
CHECKED	19-5-82	
DRAWN	13-6-82	

PLANT NORTH U.O.N

CLIENT THE NORTHERN TERRITORY OF AUSTRALIA DEPARTMENT OF TRANSPORT & WORKS

TITLE RUM JUNGLE REHABILITATION PROJECT
WATER TREATMENT PLANT
PLANT LAYOUT

SIZE B1 SCALE 1:100

REV. No 0

DRAWING No RJR-00/G-001

Technical reference to the Water Treatment Study:

APPENDIX 1

REPORT OF WORKING GROUP - SUMMARY APRIL 1978 -

TABLE 8. PAGE 68

TABLE 8

THE OPEN CUTS: VOLUME, WEIGHT OF ROCK EXCAVATED

AND PRESENT UNFILLED VOLUME

	Original Volume Million cubic meters	Weight of rock Extracted million tonnes	Present Un-filled Volume million cubic metres
White's open cuty	3.5	8.5	2.5
Dyson's open cut	0.92	2.5	0.7
Intermediate open cut	0.97	2.5	0.95

NOTES:

1. Rock extracted includes ore and overburden.
2. Dyson's open cuty was filled with tailings to the lowest point of the perimeter.
3. Volume estimates are accurate to $\pm$ 20%

Technical reference to the Water Treatment Study:

APPENDIX 2

AUSTRALIAN MINING & SMELTING

8th COMMONWEALTH MINING & METALLURGICAL CONFERENCE

CHAPTER 9

URANIUM

Collated by M. L. FITZGERALD[1] and F. R. HARTLEY[2]

INTRODUCTION[3]

The search for uranium in Australia was begun in 1944 when, at the request of the United Kingdom Government, the Commonwealth and South Australian Governments examined Radium Hill and Mount Painter which had both been discovered before World War I. By 1950 a treatment method had been developed for Radium Hill ore and sufficient ore reserves proved to justify the installation of a treatment plant.

In 1948 tax free rewards were introduced by the Commonwealth Government for discoveries of uranium ore. This was followed in 1949 by the establishment of a uranium buying pool and in 1952 by the exemption from income tax of profits derived from the mining and treatment of uranium ores. One result of these encouragements to prospecting was the discovery of the first Rum Jungle orebody in the Northern Territory in 1949.

Contracts for the supply of uranium from both Radium Hill and Rum Jungle were entered into with the Combined Development Agency in 1952 and production from both properties commenced in 1954.

Prospecting in Australia continued and as a result of clarification of the conditions under which private prospectors and mining companies could participate in the search for, and exploration of, uranium deposits, a widespread uranium prospecting boom commenced in 1954. This boom resulted in the discovery and exploitation of Mary Kathleen near Mt. Isa in Queensland, and United Uranium and South Alligator Uranium in the South Alligator River area of the Northern Territory.

[1] General Manager, Rio Tinto Brick Pty. Limited.
[2] Officer in Charge, Industrial Chemistry, The Australian Mineral Development Laboratories.

Thus in 1960 there were the following five producers.

1. Territory Enterprises Pty. Ltd., at Rum Jungle, N.T.
2. Mary Kathleen Uranium Ltd., at Mary Kathleen, Qld.
3. The Radium Hill Project at Radium Hill, S.A., with its associated concentrate treatment plant at Port Pirie, S.A.
4. United Uranium N.L. at Moline, N.T.
5. South Alligator Uranium N.L. at El Sherana, N.T.

The location of these producers is shown on the general map in Chapter 2.

In the late 1950s the demand for uranium suffered a severe setback and no further contracts were signed. As each company reached the end of its contract, operations ceased, and at the end of 1964 Rum Jungle was the sole surviving producer. The main features of each operation are shown in Table 1.

With the exception of the Rum Jungle ion exchange process, the development of suitable treatment processes for all these operations was carried out by the South Australian Mines Department, which became The Australian Mineral Development Laboratories in 1960.

RUM JUNGLE[4]

Introduction

Rum Jungle is 40 air miles south of Darwin to which it is connected by both a railway and a sealed road.

Although there are reports of prospecting activity in the area extending over almost a century it was not until

[3] By M. L. Fitzgerald, General Manager, Rio Tinto Brick Pty. Ltd.
[4] By T. Barlow, Manager, Territory Enterprises Pty. Ltd.

TABLE 1
Australian uranium producers

	Rum Jungle	Mary Kathleen	Radium Hill/ Port Pirie	United Uranium	South Alligator
Location	N.T.	Q'ld.	S.A.	N.T.	N.T.
Initial development	1949	1954	1944	1954	1954
Production commenced	1954	1958	1954	1959	1959
Operations ceased	—	1963	1962	1964	1962
Tons ore treated[1]	609,600	2,900,000	n.a.	121,300	14,500
Production (lb U_3O_8)[1]	3,814,300	9,000,000	n.a.	1,013,500	308,000

[1] To the end of 1963. n.a. Not available.

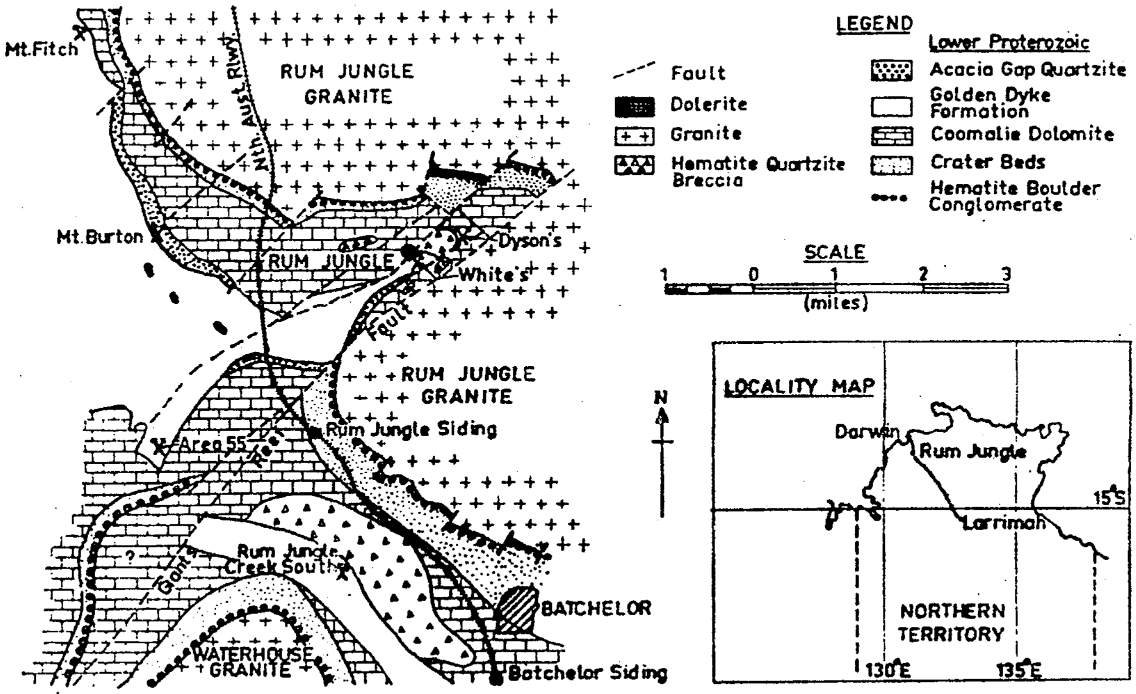


FIG. 1.—General location and geology of Rum Jungle area.

1949 that detailed investigations were commenced. In that year a local prospector reported the resemblance between minerals at the site of what was later to become White's mine and uranium minerals illustrated in a Bureau of Mineral Resources (B.M.R.) publication. Geological investigations were immediately initiated by the B.M.R., acting on behalf of the Commonwealth Department of Supply. By 1952 sufficient reserves had been proved for the finalization of an agreement with the Combined Development Agency (an organization established by the British and United States Governments to finance both the development of uranium deposits and the purchase of uranium oxide) for the provision of funds for the early development of the project. Subsequently, in addition to White's, orebodies at Dyson's and Rum Jungle Creek South were developed.

In January 1953, Consolidated Zinc Pty. Ltd. took over the organization of the project at the Commonwealth's request and formed a subsidiary company, Territory Enterprises Pty. Ltd., to manage all operations at Rum Jungle.

Geology

Sedimentary rocks in the area consist of a group of shelf type deposits of grits, quartzites, conglomerates, and dolomites which are overlain by a group of trough type deposits of slates. The sediments are of Lower Proterozoic Age. Two granite masses have intruded the sediments and occupy the cores of adjacent domes (Fig. 1).

The major structural feature in the area is Giant's Reef fault which cuts through the Rum Jungle granite and surrounding sediments, the lateral displacement being approximately 3½ miles. Relief of stress was aided by intense shearing of the slates and by the development of smaller faults and shear zones.

The mineralization occurs in these highly sheared and faulted slates. The primary uranium mineral is uraninite and at White's and Dyson's open cut, where the orebodies outcropped, the uraninite has been altered to torbernite, saleeite, autunite, sklodowskite, and uranium ochres, above the base of oxidation.

At Rum Jungle Creek South (R.J.C.S.), where the top of the orebody lay 100 ft below the surface, uraninite was the only mineral. At White's mine the uranium-copper orebody was overlain stratigraphically by a copper orebody which in turn was overlain by lead-cobalt-nickel mineralization. Treatment of this ore is discussed in the chapter on copper. All of the orebodies contain pyrite in varying amounts and some of the mineralized slates are graphitic.

Mining

Three orebodies, namely White's, Dyson's, and R.J.C.S. have been mined, all by open cut methods. Exploratory development revealed the host and adjacent rock types to be extremely incompetent and the mineralization irregular. The exploratory openings indicated beyond doubt that the support of large area openings in an underground mine would have been very costly and difficult, and that ore dilution would have been significant. The dilution problem was of considerable importance since Rum Jungle ores and waste rock are very high acid consumers.

The physical characteristics of the rock types were such that batters, which would keep the overburden to ore ratios within acceptable limits, could only be expected to remain stable if the cut lives were not prolonged. In effect, this meant extracting ore at a rate far in excess of treatment requirements.

White's and Dyson's

White's and Dyson's orebodies were mined under contract as conventional shovel and rear dump truck operations, the Dyson's excavation being undertaken concurrently with the latter part of White's.

The contractor's equipment was comprised of

1. two diesel powered Manitowoc 4500 excavators with 5½ cu. yd. buckets,
2. two diesel powered 33RB Ruston Bucyrus excavators with 1¼ cu. yd. buckets,
3. twelve 31TD Euclid rear dump trucks,
4. three Leyland Hippo rear dump trucks,
5. two Caterpillar D8 bulldozers,
6. one Caterpillar No. 12 motor grader,
7. one Quarrymaster drilling unit,
8. one Drillmaster drilling unit (replacement for 7 above), and
9. one Halco-Stenwick wagon drill.

The Manitowoc shovels were employed on overburden removal on a nominal 25 ft face height. Drilling patterns varied with the rock types and ranged from 20 ft by 15 ft in the slates to 10 ft by 10 ft in the foot wall limestone. The 6 in. Quarrymaster and Drillmaster holes were charged with 5 in. Quarrigel explosive which was detonated with Cordtex. Blasting ratios varied from 6 cu. yd./lb in the softer slates to 1 cu. yd./lb in the limestone.

The average rock density was 2 ton/cu. yd.

For ore extraction a face height of 7–10 ft was employed. This, combined with the small bucket size of the 33RB Ruston Bucyrus shovels and close and continuous monitoring of the ore faces with portable ratemeters gave satisfactory selectivity. Borehole probing of the 4 in. Halco Stenwick shot holes ahead of the face was of some assistance in delineating ore contours but usually the spacing of the drilling pattern was too broad for close control.

Rum Jungle is situated within the monsoonal belt and has an average rainfall of 60 in. year confined to the period November–March. The shales and slates of the orebodies when wet became very slushy under heavy earthmoving and transport equipment, and ore extraction during this period resulted in substantial ore losses. Consequently mining during the wet season was confined to overburden removal, operations having previously been scheduled to leave sufficient overburden above a substantial sump to satisfy excavation requirements during this season.

Mining of the White's and Dyson's orebodies involved the excavation of 4,620,000 cu. yd. at an overburden : ore ratio of 28 : 1, and 1,200,000 cu. yd. at an overburden : ore ratio of 15 : 1 respectively. An individual batter slope of 50 ft in 20 ft relieved with 15 ft berms at 50 ft intervals was employed in both cases. With a 40 ft spiral road approach on a gradient ranging from 1 in 20 to 1 in 15 this gave an overall batter angle of 40° in White's open cut which was 365 ft deep and a correspondingly steeper slope in Dyson's which was 150 ft deep. A total of 750 million gal of water was pumped from White's during its 4 year life.

The ore reserve estimates for White's indicated a reserve tonnage of 264,000 tons of uranium ore averaging 7·7 lb U_3O_8/ton and 3·8 per cent copper. Actual extraction from the orebody totalled 261,000 tons assaying 7·39 lb U_3O_8/ton and 3·4 per cent copper. In addition, 40,000 ton of ore were recovered from outside the orebody proper giving a total production of 301,000 tons assaying 7·24 lb U_3O_8/ton and 3·0 per cent copper.

An additional 290,000 tons of copper ore assaying 2·8 per cent copper were won from the excavation. At Dyson's, ore production totalled 175,000 tons of uranium ore assaying 7·66 lb U_3O_8/ton compared with the reserve estimate of 190,000 tons averaging 6·1 lb U_3O_8/ton.

Rum Jungle Creek South

At R.J.C.S. a shallow depth seismic investigation indicated that the majority of the rock types were suitable for ripping and consequently bulldozers with hydraulic rippers working in conjunction with tractor-scraper combinations were employed for excavating overburden and waste rock. The ore extraction techniques were similar to those employed at White's and Dyson's. Some blasting of the orebody was undertaken to facilitate loading. Ammonium nitrate-fuel oil (AN-FO) mixture was used as the explosive.

The R.J.C.S. contractor used

1. five Caterpillar DW21 scrapers, 20 cu. yd. struck capacity,
2. two Caterpillar 619 scrapers, 16·5 cu. yd. struck capacity,
3. two Caterpillar D9 bulldozers with hydraulic rippers,
4. one Caterpillar D8 bulldozer with hydraulic rippers,
5. one Caterpillar D6 bulldozer,
6. one Caterpillar No. 12 grader,
7. one diesel powered 54RB Ruston Bucyrus excavator with 2½ cu. yd. bucket,
8. one diesel powered 38B Bucyrus Erie excavator with 1¼ cu. yd. bucket, and
9. four Atlas Copco wagon drills.

The original open cut design incorporated an overall batter angle of 1½ : 1 for the first 50 ft from the surface and 1 : 1 for the remaining 190 ft of the excavation. A spiral road approach involving a 30 ft road on a gradient of 1 in 15 was included in the design. Whilst this overall batter angle proved satisfactory for half of the perimeter of the cut, the heavily leached chloritic slates comprising the overburden to 100 ft in the southern section of the cut proved unstable at this slope, and some batter collapse occurred in which classical "rotational shear" failure was exhibited. Although the cut was only 100 ft deep at the time of this subsidence the leached slate had very little cohesion and a final batter slope for the first 100 ft of the excavation of only 16° was necessary to stabilise the batter in this section.

The R.J.C.S. excavation involved the removal of 2,940,000 cu. yd. for the recovery of 653,000 tons of uranium ore assaying 9·6 lb U_3O_8/ton. **A total of 208 million gal of water was pumped from the R.J.C.S. excavation during its 2 year life.**

Ore treatment

Fig. 2 shows the present treatment plant flowsheet and Fig. 3 a general view of the plant. Current ore is from the Rum Jungle Creek South open cut, in which uraninite is the only uranium mineral.

Crushing

The ore leaches readily in the rain and all outside stockpiles have been covered with hessian sprayed with a bitumen emulsion. A steel frame building of rated capacity 65,000 ton is used to ensure a continuous supply of dry ore in the wet season.

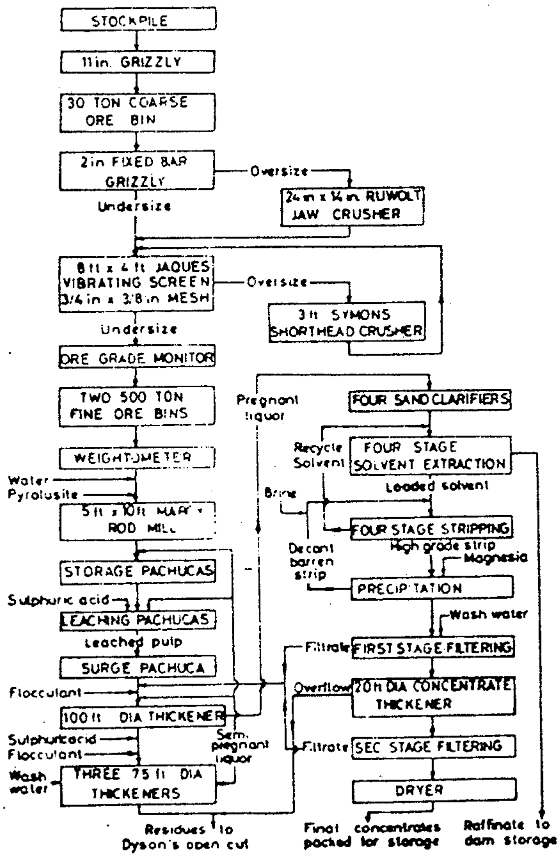


FIG. 2.—Flowsheet of the Rum Jungle treatment plant.

FIG. 3.—General view of the Rum Jungle treatment plant.

Ore from stockpile is delivered to a 30 ton coarse ore bin fitted with an 11 in. grizzly. A 30 in. apron feeder delivers from the bin to a fixed bar grizzly of nominal spacing 2 in., oversize passing to a 24 in. by 14 in. Ruwolt jaw crusher. Crusher product and grizzly undersize are conveyed to an 8 ft by 4 ft Jaques double-deck cascade screen, fitted with a 1½ in. top deck and ¾ in. by ⅜ in. bottom deck. Screen oversize is crushed in a 3 ft Symons short-head cone crusher set at ½ in. which is in closed circuit with the vibrating screen. Screen undersize is conveyed to two fine ore bins each of 500 ton capacity. Dust collection is carried out by a size 20 type N Rotoclone unit.

Pyrolusite used as an oxidant during leaching is crushed through the same plant into a 100 ton bin and is blended with the feed to the grinding section.

Grinding

Each fine ore bin is equipped with four variable speed 18 in. belt feeders, whilst the pyrolusite bin is equipped with one similar feeder. Crushed ore and pyrolusite are conveyed over a Blake-Denison weightometer to a 5 ft by 10 ft Marcy rod mill driven by a 100 h p. electric motor.

Ore is ground in open circuit at 70 per cent solids to 51 per cent minus 200 mesh B.S.S. The pulp is diluted to 62 per cent solids with semi-pregnant liquor at pH 1·4 from the second thickener in the liquid-solid separation circuit before pumping directly to storage pachucas. Kroball rods of 3 in. diameter are used as the grinding media. Mill liners are of the wave type. Milling rate is normally 16·0 t.p.h.

Leaching

Milled pulp is stored in three rubber lined pachucas, each holding up to 120 tons of ore. After further dilution to 53 per cent solids with semi-pregnant liquor, pulp is leached in batches of 34 tons in two smaller pachucas by an addition of 125 lb of 98·5 per cent sulphuric acid per ton of ore. Pyrolusite addition is equivalent to 7 lb manganese dioxide per ton of ore. Preliminary leaching time is 2½ hr and the pulp is then transferred to a surge pachuca from which the leached pulp is pumped to the first thickener in the counter-current decantation circuit. Throughput is 200 t.p.d.

Liquid-solid separation

Liquid-solid separation is carried out in a four-stage counter-current decantation plant. The first thickener is a 100 ft diameter Dorr torque type AR with adjustable rakes. The other three thickeners are 75 ft diameter Dorr type SR. All thickeners are rubber lined and have stainless steel cones.

Thickener underflow densities are maintained at approximately 50 per cent solids and slime level is held at a minimum. Gum guar is used as a flocculant at the rate of 0·38 lb/ton of ore treated. Acid is added to the repulper for the second stage thickener at the rate of 50 lb ton of ore. Pregnant liquor (approximately 1·0 g/l. U_3O_8) overflowing the first thickener is pumped to the solvent extraction circuit at pH 1·35–1·45.

Overall recovery in the leaching and liquid-solid separation sections is 96–97 per cent.

Solvent extraction

For many years the uranium was concentrated by ion exchange but solvent extraction is now used. Solvent is Alamine 336 (tricaprylyl amine) and is used as a 5 per cent solution in aviation kerosene. Modifier is a 3 per cent addition of Nonanol.

Pregnant liquor is clarified in four pressure sand clarifiers operated in parallel. These columns, formerly used for ion exchange, are rubber lined, 7 ft diameter by 12 ft high. One column per shift is back-washed with water at 270 gal/min.

Clarified pregnant liquor controlled at 130 gal/min passes directly to the first extractor of the solvent extraction section, which consists of four stages of extraction followed by four stages of stripping. An internal type of mixer-settler unit is used for the stagewise contact of solvent and aqueous phases.

The four extractors are 12 ft diameter by 10 ft deep and the internal mixing tank is 4 ft 6 in. diameter by 3 ft 6 in. deep. Agitation in the mixing tank is provided by a stainless steel turbine type impeller. The stripping units are 5 ft diameter by 6 ft deep and the mixer dimensions are 30 in. diameter by 30 in. deep. All extraction and stripping units are mild steel lined with epoxy resin reinforced with glass cloth.

Recycle solvent is metered into No. 4 extractor and gravitates through No. 3, No. 2, and No. 1 extractors, increasing in uranium concentration as it passes counter current to the pregnant liquor. Pregnant liquor is transferred between stages by pumping with 4/3 split-casing Warman pumps. The aqueous phase contains 0·001 g/l. U_3O_8 as it leaves No. 4 extractor.

Loaded solvent from the extraction section is metered into the mixer of No. 1 stripper while fresh strip solution at 1·0 *M* sodium chloride flows counter current from the fourth stripper. Air lifts are used for the interstage transfer of the aqueous phase. The high grade strip solution from the first stripper is pumped to the precipitation section.

The solvent flow is varied, depending on the uranium content of the pregnant liquor, to obtain a loaded solvent value of 5·6–6·0 g/l. U_3O_8. The solvent to strip solution flow ratio is held constant at 5 : 1 giving a high grade strip value of 26–30 g/l. U_3O_8. Recycle solvent value is generally 0·2 g/l. U_3O_8.

Precipitation and washing

The high grade strip from solvent extraction is precipitated after heating to 85°C with live steam in two precipitation tanks 12 ft diameter by 9 ft cylindrical section with a 60° conical bottom. Batch precipitation is employed using a magnesia slurry at 25 per cent solids to give a final pH of 6·8. Magnesia consumption averages 0·27 lb/lb U_3O_8 precipitated.

After precipitation the concentrate is allowed to settle in the precipitation tank with the aid of a small amount of Superfloc 16. The clear solution is decanted and used to make up fresh strip solution.

The settled concentrate at 35 per cent solids is pumped into a 4000 gal rubber lined conical bottom vessel which contains water heated to 85°C with live steam. The hot water wash dissolves any unreacted magnesia and some sulphate. After washing and settling, the concentrate is pumped to a 3 ft diameter by 4 ft rotary drum filter. Wash water is used on the filter and the filter cake is repulped with water before passing to a 20 ft diameter Dorr torque thickener with adjustable rakes. The concentrate from the thickener at approximately 35 per cent solids is filtered on a similar filter. The chloride content of the final concentrate is thus kept below 0·02 per cent NaCl. The overflow from the concentrate thickener is sent to waste after clarification to recover a small amount of entrained uranium.

Product drying

The cake from the second stage filter is delivered to an extruder which consists of a roller oscillating over a punched plate extruding through $\frac{3}{16}$ in. diameter holes on to an endless stainless steel conveyor. The concentrates are dried to 2 per cent moisture with infra-red strip heaters. Any dust in the dryer gases from other portions of the dryer and from concentrate sampling is collected in a size 2½ type N Rotoclone unit. The concentrate from the drying belt is packed in 44 gal open top drums, with a plastic bag liner. Concentrate is sampled by an auger sampler, using a template and a series of random numbers. The drums are sealed, weighed, and repainted before storing.

Disposal of residue and effluent

The residue from the liquid-solid separation thickener circuit is pumped 2800 ft to Dyson's open cut from which clear water is decanted. The raffinate from the solvent extraction section is pumped through a 4 in. polythene line to dam storage.

All other effluents such as floor washings and concentrate thickener overflow are discarded with the residue.

Water

Most of the water for the plant is obtained from White's open cut, which was allowed to fill when mining terminated. The water is slightly acidic, and neutralized water is used in the plant and at any point where corrosion can occur.

MARY KATHLEEN URANIUM LTD.[1]

Introduction

Mary Kathleen is in the Cloncurry mineral field, about 40 miles due east of Mount Isa and 500 miles west of Townsville, the nearest sea port. The area is sparsely covered with vegetation, the general elevation is about 1,000 ft above sea level, and the country is rugged. The average annual rainfall is 17 in. which falls as heavy showers from November to mid-March. There are no permanent water courses and the climate is generally hot and dry with an average evaporation rate of 108 in./year.

The discovery of the Mary Kathleen orebody in 1954 was the result of some three months of intensive prospecting by a syndicate of eight members led by Mr. C. Walton and Mr. N. McConachy.

By March 1956 diamond drilling, geological mapping, and metallurgical research had proceeded to the extent that a contract for the supply of uranium to the value of £40 million was negotiated between the United Kingdom Atomic Energy Authority (U.K.A.E.A.), Mary Kathleen Uranium Ltd., and the Rio Tinto Mining Company of Australia. The latter company was the major shareholder and manager of the operating company. The necessary funds of approximately £13 million were provided by the U.K.A.E.A., Rio Tinto, and Australian banking houses.

Because of the total absence of services of any kind, it was necessary to plan and develop a township, water supplies, power, and other services in addition to the mining and metallurgical facilities. These were completed before June 1958, when production commenced. When the contract with the U.K.A.E.A. was completed in November 1963, the property was closed down and placed on a caretaker basis.

Geology

The orebody occurs in the axial zone of a local synclinal structure in the Corella Beds of Lower Proterozoic age. The Corella Beds were originally impure calc-silicates and have been altered locally by metamorphism and metasomatism to garnet-diopside-apatite-scapolite granulites.

Within the garnet skarn, garnet replaced the diopside of the diopside granulite and in turn the garnet was in part replaced by the rare earth minerals allanite and stillwellite, which carry the microscopic uraninite.

Allanite is by far the more common ore host mineral. Within the areas of major allanite replacement, there is no recognizable control and even when the underlying fracture control can be recognized, it is seldom persistent. The distribution of mineralization can be pictured as an irregular honeycomb of connected shoots of mineralization separated by waste blocks. The ore-shoots vary in width from a few feet to 150 ft.

Mining

Open cut design

Fig. 4 shows the design of the open cut and Fig. 5 a general view in 1963. Because the garnet-diopside host rock is barren, selective mining was adopted, and for this reason the design provided for 25 ft benches, finishing with 50 ft face heights and berm widths of 15 ft giving an overall batter of 50°. Consequently, mining costs were approximately double those of conventional open-cut mining.

Selective mining

To maintain minimum dilution, selective mining was carried out as follows.

Bench mapping. Geological mapping was carried out as a daily routine, commencing with prior monitoring and marking of the bench faces. The faces were scaled down after firing, hosed with water, monitored with a Phillips hand-held geiger counter, and with visual assistance the outline of the ore shoot was traced out in chalk, and then painted to identify waste and two types of ore.

Significant fractures were measured and sketched in longitudinal section. Together with the reference numbers on the prepared mapping sheet these fractures built up the skeletal framework used when sketching the interpretation of ore from the monitored bench face. Horses of waste were delineated if they were large enough to show on the mapping scale.

The intersections of the ore occurrence and the various features with the reference elevation were then projected to plan.

Drilling. Vertical down holes 2¾ in. in diameter were percussion drilled 6 ft behind the face on a spacing o 8 ft. These holes were drilled to a depth of 27 ft or 35 ft using 10 ft extension drill rods.

Survey and probing. All vertical blast holes were surveyed and probed as a daily routine, and each hole was identified by a numbered plate which remained to identify the hole until it was fired.

Probing of the down holes was carried out concurrently with the survey. Readings taken at 1 ft intervals as the probe was raised were manually recorded and later divided into significant intersections of ore waste or depending on whether the value was above or below the cut-off grade.

Selective blasting. Normal firings were usually 1,000 to 2,000 tons, the position and nature of firings being dependent on the state of the benches, shovel availability, and mill requirements. A certain group of holes was selected to provide either an ore or a waste firing. All down holes were fired only after the issuing of firing instructions by the geologist which identified the bench, section, hole numbers, and depths to which individual holes were to be fired. Decision on waste firings was

[1] By P M Wreford, formerly General Manager of Operations, Mary Kathleen Uranium Ltd.

Technical reference to the Water Treatment Study:

APPENDIX 3

CHEMICAL TREATMENT OF WHITES PIT WATER AND THE INTERMEDIATE PIT WATER - RUM JUNGLE MINE

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CHEMICAL TREATMENT OF WHITES PIT WATER

AND THE INTERMEDIATE PIT WATER.

RUM JUNGLE MINE

K.G.M. Cooper, J. F. Alcock, G. M. Johnston

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SYNOPSIS

Two pits, White and the Intermediate located at the abandoned Rum Jungle Mine site contain high sulphuric acid and metal concentrations. Laboratory experiments were conducted to determine the potential of a range of alkaline chemicals to neutralize acidity and precipitate heavy metals. The effect of the treatment on macro-ion concentrations is also noted.

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1. INTRODUCTION

The Northern Territory Government is considering the feasibility of rehabilitating the Rum Jungle Mine.

Two pits, Whites and the Intermediate contain sulphuric acid and high concentrations of dissolved metals. Their volumes are approximately 3.5 x $10^6 m^3$ and 1.5 x $10^6 m^3$ respectively (Reference 1).

The capacity of some common neutralizing agents for acid and heavy metal removal was examined by laboratory experiment during October - November, 1981. The experimental results for the treatment of Whites pit water with sodium hydroxide, and lime-sodium carbonate are given in Appendix "A".

The effects of sodium hydroxide, slaked lime, limestone and sodium aluminate on water from the Intermediate pit are given in Appendix "B".

A detailed list of tests is given in Appendix "A" and "B" and the index to these is found in the List of Tables and List of Figures.

2.1 Whites Pit Water Quality

This is the most severely polluted of the two pits. About six times the alkali is required to raise Whites pit water to a given pH as is required to raise the Intermediate pit water to the same pH.

Of the total alkali required for elevation of the pH to 7, only about 5-7% is consumed in neutralization of the acid, the remainder is consumed in the formation of metal hydroxides.

The chemical analysis of water from Whites pit is shown in Table 2.1 (i).

TABLE 2.1 (i) Chemical Analysis of Whites pit water*.

pH	Specific Conductance microsiemens/cm	Ca	Mg	Na	SO_4	Mn	Fe	Cu	Ni	Co	Zn	Al	Hg	As	Ra^{226}**
							mg/L								pCi/L
2.5	9200	400	900	200	8200	230	430	55	14	15	6	280	0.01	0.4	2.0

* water from about 25 metres, taken as representative of the average water quality. October 1981.

** Surface sample taken August 1981. Analysis by Amdel.

2.2 Neutralization of Whites Pit Water

Taking sodium hydroxide as one hundred percent efficient, the efficiencies of the slaked lime treatment was calculated thus:

$$\text{Efficiency} = 100 \frac{M}{N} \%$$

Where M = The number of moles of lime to raise the pH to 7.

N = Half the number of moles of sodium hydroxide consumed to raise the pH to 7.

Efficiencies are shown in table 2.2. (i).

Table 2.2 (i)

REAGENT	EFFICIENCY PERCENTAGE
Sodium Hydroxide (24 hour)	100
Lime (slaked) (24 hour)	90

The efficiency of sodium aluminate is not given, because the stoichiometry of the sodium aluminate neutralization process is not accurately known. Limestone is not shown in the table, because valid comparisons can only be made if the reagents remove metals with comparable efficiency. Limestone does not remove manganese, cobalt nickel and zinc efficiently. The efficiency of the treatment is time dependant, particularly for limestone whose efficiency is very dependant on stirring and standing (Appendix "A").

The limestone used came from the Katherine area and assayed ninety three percent calcium carbonate.

2.3 Heavy Metal Removal. Whites Pit Water.

The percentage of metal removed relative to the raw water was calculated after adjusting the pH to 7. Efficiencies are given in table 2.3 (i).

Table 2.3 (i)

REAGENT		PERCENTAGE REMOVED					
		Mn	Fe	Cu	Ni	Co	Zn
Sodium Hydroxide	(24 hours)	61	102	100	99	98	98
Calcium oxide	(24 hours)	76	100	100	99	98	99
Calcium Carbonate	(100 hours)	9	100	100	36	20	57
Sodium aluminate	(24 hours)	57	100	100	97	95	98

Manganese is not completely precipitated at pH 7. The percentage removal increases from 61 to 83 when the pH is raised from 7 to 8 using sodium hydroxide.

2.4 The effect of neutralization on macro-ion concentrations. Whites Pit Water

Addition of neutralizing chemicals caused variation in the concentrations of major cations and anions and consequently specific conductance. Percentage changes relative to the untreated water are given in table 2.4 (i).

Table 2.4 (i)

REAGENT	PERCENTAGE* Specific Conductance	Sulphate	Calcium	Manganese	Sodium
Sodium Hydroxide	+11	10	-	13	+850
Calcium Oxide	39	47	+75	22	-
Calcium Carbonate (100 hours)	29	51	+25	+2	+10
Sodium Aluminate	10	26	13	17	+700

* Throughout this report values shown as + indicate an increase in concentration. All other table entries represent a decrease.

2.5 Treatment with Lime and Sodium Hydroxide to Elevated pH

Both magnesium and sulphate concentrations can be lowered by treatment with lime to pH 8 and then sodium hydroxide to pH 10.

Percentage changes in macro-ion concentration after treatment are given in table 2.5 (i).

Table 2.5 (i)

PERCENTAGE CHANGE SPECIFIC CONDUCTANCE	SULPHATE	CALCIUM	MAGNESIUM	SODIUM
24	51	+30	99	+650

A dosage of 2.5 g/L lime and 2.2 g/L sodium hydroxide was required. The sodium hydroxide dosage to achieve removal of magnesium and sulphate is sufficient to elevate the pH of the raw water to 6.

2.6 Treatment with lime and sodium carbonate to elevated pH

An attempt to produce a solution reduced in calcium, magnesium and sulphate by treatment with lime to pH 8 and then sodium carbonate to pH 10 resulted in successful removal of the metals but redissolution of sulphate.

Table 2.6 (i)

PERCENTAGE CHANGE SPECIFIC CONDUCTANCE	SULPHATE	CALCIUM	MAGNESIUM	SODIUM
+41	7	93	83	+1750

3.1 Intermediate Pit. Water Quality

The chemical analysis of water from the Intermediate pit is given in table 3.1 (i).

TABLE 3.1 (i) Chemical Analysis of Intermediate Pit Water

pH	Specific Conductance microsiemens/cm	Ca	Mg	Na	SO_4	Mn	Fe mg/L	Cu	Ni	Co	Zn	Al	Hg	As	Ra^{226}** pCi/L
3.5	3900	200	400	40	3100	60	2	60	14	15	7	60	0.05	0.001	1.7

** A surface sample August 1981. Analysed by AMDEL

3.2 Intermediate Pit Water. Neutralization

Assuming sodium hydroxide to be one hundred percent efficient the efficiency of lime was calculated.

Table 3.2 (i)

REAGENT	EFFICIENCY
Sodium Hydroxide	100
Lime Slaked	89

Limestone and sodium aluminate are not given for the reasons stated in Section 2.2.

3.3 Heavy Metal Removal. Intermediate Pit Water

The percentage of metal removed relative to the raw water was calculated after adjusting the pH to 7 table 3.3. (i).

Table 3.3. (i)

REAGENT	PERCENTAGE REMOVED					
	Mn	Fe	Cu	Ni	Co	Zn
Sodium hydroxide	50	100	100	99	98	98
Calcium oxide (16 hours)	33	100	100	79	81	97
Calcium oxide (7 days)	33	100	100	98	94	99
Calcium Carbonate (50 hours)	0	100	97	29	0	43
Sodium Aluminate (16 hours)	42	100	100	98	95	100

3.3 The Effect of Neutralization on macro-ion concentrations. Intermediate Pit Water

Neutralization to pH 7 caused changes to specific conductance and macro-ion constituents. Percentage changes relative to the untreated water are given in table 3.4 (i).

Table 3.4 (i)

REAGENT	PERCENTAGE				
	Specific Conductance	Sulphate	Calcium	Magnesium	Sodium
Sodium Hydroxide	+5	0	0	9	+850
Calcium oxide	3	3	+120	0	0
Calcium carbonate (50 hours)	2	6	+100	4	0
Sodium Aluminate (6 hours)	3	13	0	13	+1000

4. CONCLUSIONS

The treatment process to be used will depend on chemical costs, treatment plant costs, release standards and the water supply available for dilution of treated water. Accordingly a range of laboratory tests were conducted and the following observations on specific reagents noted.

Lime (CaO).

Lime is efficient in removal of acid and heavy metals, and the most successful in removing sulphate, but gives a considerable residue of calcium. Further removal of calcium sulphate and metals was noted on standing.

Freshly slaked lime is expected to be the most efficient because the hydrate takes up carbon dioxide to give the less soluble and weaker base calcium carbonate.

Further testing of this aspect of lime treatment is necessary.

Sodium Hydroxide (NaOH)

Sodium Hydroxide is effective in removing acid and metals but does not reduce sulphate and gives a large elevation in sodium. Reaction is immediate.

The handling of large quantities of caustic soda would require greater precautions than the reagents.

Limestone ($CaCO_3$)

After addition of sufficient limestone to raise the pH to about 4.5 the solution would require ponding and agitation for up to one hundred hours. This effects a pH rise to about 7. The treatment would probably require isolation of the treated water from the main pit.

Agitation effects oxidation of iron, removal of carbon dioxide and assists to prevent the iron precipitate coating the limestone particles thus preventing reaction.

Manganese, nickel, zinc and cobalt were not efficiently removed.

Should a local supply of limestone be found, the case for limestone could be strengthened.

Sodium Aluminate ($Na_2\ Al_2O_4$)

This showed no advantage over the previous chemicals and is probably more expensive. The availability of this or a similar chemical from Gove should be examined.

Lime, Sodium Carbonate

This does remove calcium, but requires a large sodium carbonate dosage with a consequent increase in sodium concentration. A two pond system would prevent the resolution of sulphate.

Lime, sodium hydroxide

This treatment has no advantage other than the removal of magnesium.

The acid and metal concentrations are less in the Intermediate pit water. About six times the alkali is required to treat a given volume of water from Whites pit as is required for the Intermediate pit. Coupled with the volume difference the chemical requirements will be about fourteen times as great for Whites pit.

Specific information can be gained from tables within the text and the data supplied within the appendices. These experiments should provide the basis for pilot plant trials.

REFERENCES

Davey, D.R., *Rum Jungle Environmental Studies*, The Australian Atomic Energy Commission, 1975.

APPENDIX "A"

Whites pit water. Laboratory treatment trials.

TABLE A1

WHITES PIT WATER WITH SODIUM HYDROXIDE

24 HOURS AFTER TREATMENT

pH	2.5	6.0	7.0	8.0
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	9800	10200	10500
mg/L SODIUM HYDROXIDE ADDED	-	2450	2700	3000
CALCIUM Ca mg/L	400	400	400	380
MAGNESIUM Mg mg/L	900	820	780	740
SODIUM Na mg/L	200	-	-	-
SULPHATE SO_4 mg/L	8200	7700	7400	8700

MANGANESE Mn mg/L	230	150	90	40
IRON Fe mg/L	430	12	1.1	0.1
COPPER Cu mg/L	55	0.1	0.05	0.05
NICKEL Ni mg/L	14	1.6	0.2	0.1
COBALT Co mg/L	15	2.0	0.3	0.1
ZINC Zn mg/L	6	0.4	0.1	0.05

TABLE A2

WHITES PIT WATER WITH SODIUM HYDROXIDE

7 DAYS AFTER TREATMENT

pH	2.5	6.6	7.0	7.4
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	10500	10900	11200
mg/L SODIUM HYDROXIDE ADDED	-	2450	2700	3000
CALCIUM Ca mg/L	400	480	440	440
MAGNESIUM Mg mg/L	900	820	780	720
SODIUM Na mg/L	200	1700	1900	2000
SULPHATE SO_4 mg/L	8200	8600	8500	8500
MANGANESE Mn mg/L	230	170	90	60
IRON Fe mg/L	430	0.1	0.1	0.1
COPPER Cu mg/L	55	0.1	0.05	0.05
NICKEL Ni mg/L	14	0.8	0.1	0.1
COBALT Co mg/L	15	0.3	0.1	0.1
ZINC Zn mg/L	6	0.3	0.05	0.05

TABLE A3

WHITES PIT WATER WITH SLAKED LIME

24 HOURS AFTER TREATMENT

pH	2.5	6.0	7.0	8.0
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	6400	5600	5400
mg/L LIME ADDED	-	1900	2100	2400
CALCIUM Ca mg/L	400	750	700	700
MAGNESIUM Mg mg/L	900	800	700	650
SODIUM Na mg/L	200	-	-	-
SULPHATE SO_4 mg/L	8200	4300	4350	4300

MANGANESE Mn mg/L	230	150	55	25
IRON Fe mg/L	430	30	0.3	0.1
COPPER Cu mg/L	55	0.5	0.05	0.05
NICKEL Ni mg/L	14	4.6	0.2	0.1
COBALT Co mg/L	15	5.3	0.3	0.1
ZINC Zn mg/L	6	1.1	0.05	0.05

TABLE A4

WHITES PIT WATER WITH SLAKED LIME

7 DAYS AFTER TREATMENT

pH	2.5	5.0	6.4	6.9
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	6200	5500	5300
mg/L LIME ADDED	-	1900	2100	2400
CALCIUM Ca mg/L	400	500	500	500
MAGNESIUM Mg mg/L	900	800	700	600
SODIUM Na mg/L	200	200	200	150
SULPHATE SO_4 mg/L	8200	5200	4000	3800

MANGANESE Mn mg/L	230	150	50	40
IRON Fe mg/L	430	2.3	0.1	0.1
COPPER Cu mg/L	55	2.4	0.05	0.05
NICKEL Ni mg/L	14	4.1	0.1	0.1
COBALT Co mg/L	15	5.9	0.1	0.1
ZINC Zn mg/L	6	1.2	0.05	0.05

TABLE A5

WHITES PIT WATER WITH LIMESTONE

		10 Mins Stir	4 Hours Stir	5 Hours Stir
pH	2.6	4.0	4.4	4.5
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	-	8000	7000
mg/L LIMESTONE ADDED	-	3500	3500	3500
CALCIUM Ca mg/L	400			550
MAGNESIUM Mg mg/L	900			900
SODIUM Na mg/L	200			220
SULPHATE SO_4 mg/L	8200			4800

MANGANESE Mn mg/L	230			220
IRON Fe mg/L	430			0.1
COPPER Cu mg/L	55			1.4
NICKEL Ni mg/L	14			12
COBALT Co mg/L	15			16
ZINC Zn mg/L	6			3.0

TABLE A6

WHITES PIT WATER WITH LIMESTONE

		10 Mins Stir	3 Hours Stir	50 Hours Stir	100 hours Stir
pH	2.5	4.5	6.0	6.7	7.0
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	-	-	6900	6500
mg/L LIMESTONE ADDED	-	4200	4200	4200	4200
CALCIUM Ca mg/L	400			780	500
MAGNESIUM Mg mg/L	900			920	960
SODIUM Na mg/L	200			260	220
SULPHATE SO_4 mg/L	8200			8200	4000

MANGANESE Mn mg/L	230			210	210
IRON Fe mg/L	430			0.8	0.3
COPPER Cu mg/L	55			0.7	0.1
NICKEL Ni mg/L	14			12	9
COBALT Co mg/L	15			12	12
ZINC Zn mg/L	6			2.6	2.6

TABLE A7

WHITES PIT WATER WITH LIMESTONE

		10 Mins Stir	4 Hours Stir	50 Hours Stir
pH	2.6	4.4	5.8	6.7
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	-	7800	6600
mg/L LIMESTONE ADDED	-	5500	5500	5500
CALCIUM Ca mg/L	400			600
MAGNESIUM Mg mg/L	900			950
SODIUM Na mg/L	200			220
SULPHATE SO_4 mg/L	8200			5100
MANGANESE Mn mg/L	230			230
IRON Fe mg/L	430			0.5
COPPER Cu mg/L	55			36
NICKEL Ni mg/L	14			15
COBALT Co mg/L	15			17
ZINC Zn mg/L	6			5

TABLE A8

WHITES PIT WATER WITH SODIUM ALUMINATE

24 HOURS AFTER TREATMENT

pH	2.5	5.0	6.0*	7.0	8.0
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	7900	8200	8300	8300
mg/L SODIUM ALUMINATE ADDED	-	2550	2900	3800	4800
CALCIUM Ca mg/L	400	400	400	350	300
MAGNESIUM Mg mg/L	900	850	800	750	550
SODIUM Na mg/L	200	-	-	-	-
SULPHATE SO_4 mg/L	8200	6300	6100	6000	5500

MANGANESE Mn mg/L	230	200	160	100	25
IRON Fe mg/L	430	110	35	0.6	0.5
COPPER Cu mg/L	55	16	0.3	0.05	0.1
NICKEL Ni mg/L	14	8.7	3.8	0.4	0.1
COBALT Co mg/L	15	9.3	4.7	0.7	0.1
ZINC Zn mg/L	6	6	0.6	0.1	0.05

TABLE A9

WHITES PIT WATER WITH SODIUM ALUMINATE

7 DAYS AFTER TREATMENT

pH	2.5	4.5	5.4	6.3	7.2
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	8450	8700	8700	8750
mg/L SODIUM ALUMINATE ADDED	-	2500	2900	3800	4800
CALCIUM Ca mg/L	400	450	420	400	350
MAGNESIUM Mg mg/L	900	800	800	750	550
SODIUM Na mg/L	200	880	1100	1300	1600
SULPHATE SO_4 mg/L	8200	6600	6600	6700	6500

MANGANESE Mn mg/L	230	180	170	110	60
IRON Fe mg/L	430	60	0.5	0.2	0.1
COPPER Cu mg/L	55	30	0.9	0.05	0.05
NICKEL Ni mg/L	14	11	2.8	0.1	0.1
COBALT Co mg/L	15	14	6.1	0.4	0.1
ZINC Zn mg/L	6	5.1	0.8	0.05	0.05

TABLE A10

WHITES PIT WATER WITH SLAKED LIME TO pH 8 THEN SODIUM HYDROXIDE

24 HOURS AFTER TREATMENT

pH	2.6	9.0	10.0	11.0
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	6000	7000	7800
LIME mg/L ADDITION	-	2500	2500	2500
SODIUM HYDROXIDE mg/L	-	1000	2200	3000
CALCIUM Ca mg/L	400	500	520	580
MAGNESIUM Mg mg/L	900	520	6	1
SODIUM Na mg/L	200	640	1500	1700
SULPHATE SO_4 mg/L	8200	4200	4000	4500
MANGANESE Mn mg/L	230	7	0.1	0.1
IRON Fe mg/L	430	0.1	0.1	0.1
COPPER Cu mg/L	55	0.05	0.05	0.05
NICKEL Ni mg/L	14	0.1	0.1	0.1
COBALT Co mg/L	15	0.1	0.1	0.1
ZINC Zn mg/L	6	0.05	0.05	0.05

TABLE A11

WHITES OPEN CUT COMPOSITE SAMPLE
SLAKED LIME TO pH 8 THEN SODIUM CARBONATE

24 HOURS AFTER TREATMENT

pH	2.6	9.0	9.5	10.0
SPECIFIC CONDUCTANCE Microsiemens /cm	9200	6300	10900	13000
LIME mg/L	-	2100	2100	2100
SODIUM CARBONATE mg/L	-	400	2000	4000
CALCIUM Ca mg/L	400	800	850	30
MAGNESIUM Mg mg/L	900	700	500	150
SODIUM Na mg/L	200	340	2400	3700
SULPHATE SO_4 mg/L	8200	5400	7700	7600

MANGANESE Mn mg/L	230	13	1.0	0.1
IRON Fe mg/L	430	0.1	0.1	0.1
COPPER Cu mg/L	55	0.05	0.05	0.05
NICKEL Ni mg/L	14	0.1	0.1	0.1
COBALT Co mg/L	15	0.1	0.1	0.1
ZINC Zn mg/L	6	0.05	0.05	0.05

APPENDIX "B"

Intermediate pit water. Laboratory treatment trials.

TABLE B1

INTERMEDIATE PIT WATER WITH SODIUM HYDROXIDE

16 HOURS AFTER TREATMENT

pH	3.5	6.0	7.0	8.0
SPECIFIC CONDUCTANCE Microsiemens /cm	3900	4000	4100	4200
SODIUM HYDROXIDE ADDED mg/L	–	370	440	550
CALCIUM Ca mg/L	200	220	210	200
MAGNESIUM Mg mg/L	460	460	420	400
SODIUM Na mg/L	40	–	–	–
SULPHATE SO_4 mg/L	3100	3100	3100	2900

MANGANESE Mn mg/L	60	40	30	10
IRON Fe mg/L	2	0.1	0.1	0.1
COPPER Cu mg/L	60	0.4	0.2	0.1
NICKEL Ni mg/L	14	2.9	0.6	0.1
COBALT Co mg/L	15	3.2	0.6	0.1
ZINC Zn mg/L	7	0.4	0.1	0.5

<u>TABLE B2</u>

<u>INTERMEDIATE PIT WATER WITH SODIUM HYDROXIDE</u>

<u>1 WEEK AFTER TREATMENT</u>

pH	3.5	6.6	7.1	7.5
SPECIFIC CONDUCTANCE Microsiemens /cm	3900	4300	4100	4100
SODIUM HYDROXIDE ADDED mg/L	-	370	440	570
CALCIUM Ca mg/L	200	240	220	220
MAGNESIUM Mg mg/L	460	460	420	400
SODIUM Na mg/L	40	320	380	420
SULPHATE SO_4 mg/L	3100	3000	3100	3000
MANGANESE Mn mg/L	60	50	30	20
IRON Fe mg/L	2	0.1	0.1	0.1
COPPER Cu mg/L	60	0.1	0.1	0.05
NICKEL Ni mg/L	14	0.7	0.1	0.1
COBALT Co mg/L	15	2.6	0.3	0.1
ZINC Zn mg/L	7	0.4	0.1	0.05

TABLE B3

INTERMEDIATE PIT WATER WITH SLAKED LIME

16 HOURS AFTER TREATMENT

pH	3.5	6.0	7.0	8.0
SPECIFIC CONDUCTANCE Microsiemens /cm	3900	3800	3800	3700
mg/L SLAKED LIME ADDED	-	300	350	400
CALCIUM Ca mg/L	200	420	440	500
MAGNESIUM Mg mg/L	460	460	460	420
SODIUM Na mg/L	40	-	-	-
SULPHATE SO_4 mg/L	3100	3100	3000	2900
MANGANESE Mn mg/L	60	45	40	20
IRON Fe mg/L	2	0.1	0.1	0.1
COPPER Cu mg/L	60	1.3	0.2	0.1
NICKEL Ni mg/L	14	8.4	2.9	0.3
COBALT Co mg/L	15	9.0	2.9	0.3
ZINC Zn mg/L	7	2.6	0.2	0.05

TABLE B4

INTERMEDIATE PIT WATER WITH SLAKED LIME

1 WEEK AFTER TREATMENT

pH	3.5	6.3	7.0	7.4
SPECIFIC CONDUCTANCE Microsiemens /cm	3900	4000	3900	4000
mg/L SLAKED LIME ADDED	-	300	350	400
CALCIUM Ca mg/L	200	440	440	500
MAGNESIUM Mg mg/L	460	480	440	400
SODIUM Na mg/L	40	45	40	40
SULPHATE SO_4 mg/L	3100	3200	3000	3000
MANGANESE Mn mg/L	60	50	40	20
IRON Fe mg/L	2	0.1	0.1	0.1
COPPER Cu mg/L	60	0.6	0.05	0.05
NICKEL Ni mg/L	14	4.5	0.3	0.1
COBALT Co mg/L	15	8.6	0.9	0.1
ZINC Zn mg/L	7	2.3	0.1	0.05

TABLE B5

INTERMEDIATE PIT WATER WITH LIMESTONE

		10 Mins Stir	4 Hours Stir	50 Hours Stir
pH	3.5	4.5	5.1	5.6
SPECIFIC CONDUCTANCE Microsiemens /cm	3900	3650	3700	3800
mg/L LIMESTONE ADDED	–	500	500	500
CALCIUM Ca mg/L	200			380
MAGNESIUM Mg mg/L	460			440
SODIUM Na mg/L	40			40
SULPHATE SO_4 mg/L	3100			3000
MANGANESE Mn mg/L	60			65
IRON Fe mg/L	2			0.1
COPPER Cu mg/L	60			30
NICKEL Ni mg/L	14			14
COBALT Co mg/L	15			18
ZINC Zn mg/L	7			7

TABLE B6

INTERMEDIATE PIT WATER WITH LIMESTONE

		10 Mins Stir	4 Hours Stir	50 Hours Stir
pH	3.5	4.6	5.9	6.3
SPECIFIC CONDUCTANCE Microsiemens /cm	3900		3800	3800
mg/L LIMESTONE ADDED	-	700	700	700
CALCIUM Ca mg/L	200			400
MAGNESIUM Mg mg/L	460			440
SODIUM Na mg/L	40			40
SULPHATE SO_4 mg/L	3100			2900
MANGANESE Mn mg/L	60			65
IRON Fe mg/L	2			0.1
COPPER Cu mg/L	60			4
NICKEL Ni mg/L	14			12
COBALT Co mg/L	15			17
ZINC Zn mg/L	7			5

TABLE B7

INTERMEDIATE PIT WATER WITH LIMESTONE

		10 Mins Stir	4 Hours Stir	50 Hours Stir
pH	3.5	4.6	6.0	6.6
SPECIFIC CONDUCTANCE Microsiemens /cm	3900	3600	3800	3850
mg/L LIMESTONE ADDED	-	1000	1000	1000
CALCIUM Ca mg/L	200			400
MAGNESIUM Mg mg/L	460			440
SODIUM Na mg/L	40			40
SULPHATE SO_4 mg/L	3100			2900

MANGANESE Mn mg/L	60			65
IRON Fe mg/L	2			0.1
COPPER Cu mg/L	60			2
NICKEL Ni mg/L	14			10
COBALT Co mg/L	15			15
ZINC Zn mg/L	7			4

TABLE B8

INTERMEDIATE PIT WATER WITH SODIUM ALUMINATE

16 HOURS AFTER TREATMENT

pH	3.5	6.0	7.0	8.0
SPECIFIC CONDUCTANCE Microsiemens /cm	3900	3800	3800	3800
mg/L SODIUM ALUMINATE ADDED	-	570	750	870
CALCIUM Ca mg/L	200	220	200	180
MAGNESIUM Mg mg/L	460	440	400	300
SODIUM Na mg/L	40	-	-	-
SULPHATE SO_4 mg/L	3100	2900	2700	2600
MANGANESE Mn mg/L	60	50	35	9
IRON Fe mg/L	2	0.1	0.1	0.1
COPPER Cu mg/L	60	0.8	0.1	0.1
NICKEL Ni mg/L	14	8	0.3	0.1
COBALT Co mg/L	15	9.5	0.7	0.1
ZINC Zn mg/L	7	1.6	0.05	0.05

TABLE B9

INTERMEDIATE PIT WATER WITH SODIUM ALUMINATE

1 WEEK AFTER TREATMENT

pH	3.5	5.9	7.3	7.8
SPECIFIC CONDUCTANCE Microsiemens /cm	3900	4000	4000	4000
mg/L SODIUM ALUMINATE ADDED	-	570	750	870
CALCIUM Ca mg/L	200	220	220	240
MAGNESIUM Mg mg/L	460	440	440	260
SODIUM Na mg/L	40	200	300	440
SULPHATE SO_4 mg/L	3100	2800	2900	2500
MANGANESE Mn mg/L	60	50	50	20
IRON Fe mg/L	2	0.1	0.1	0.1
COPPER Cu mg/L	60	3.3	0.1	0.1
NICKEL Ni mg/L	14	3.8	0.1	0.1
COBALT Co mg/L	15	8.6	0.3	0.1
ZINC Zn mg/L	7	3.4	0.05	0.05

FIG A(a)

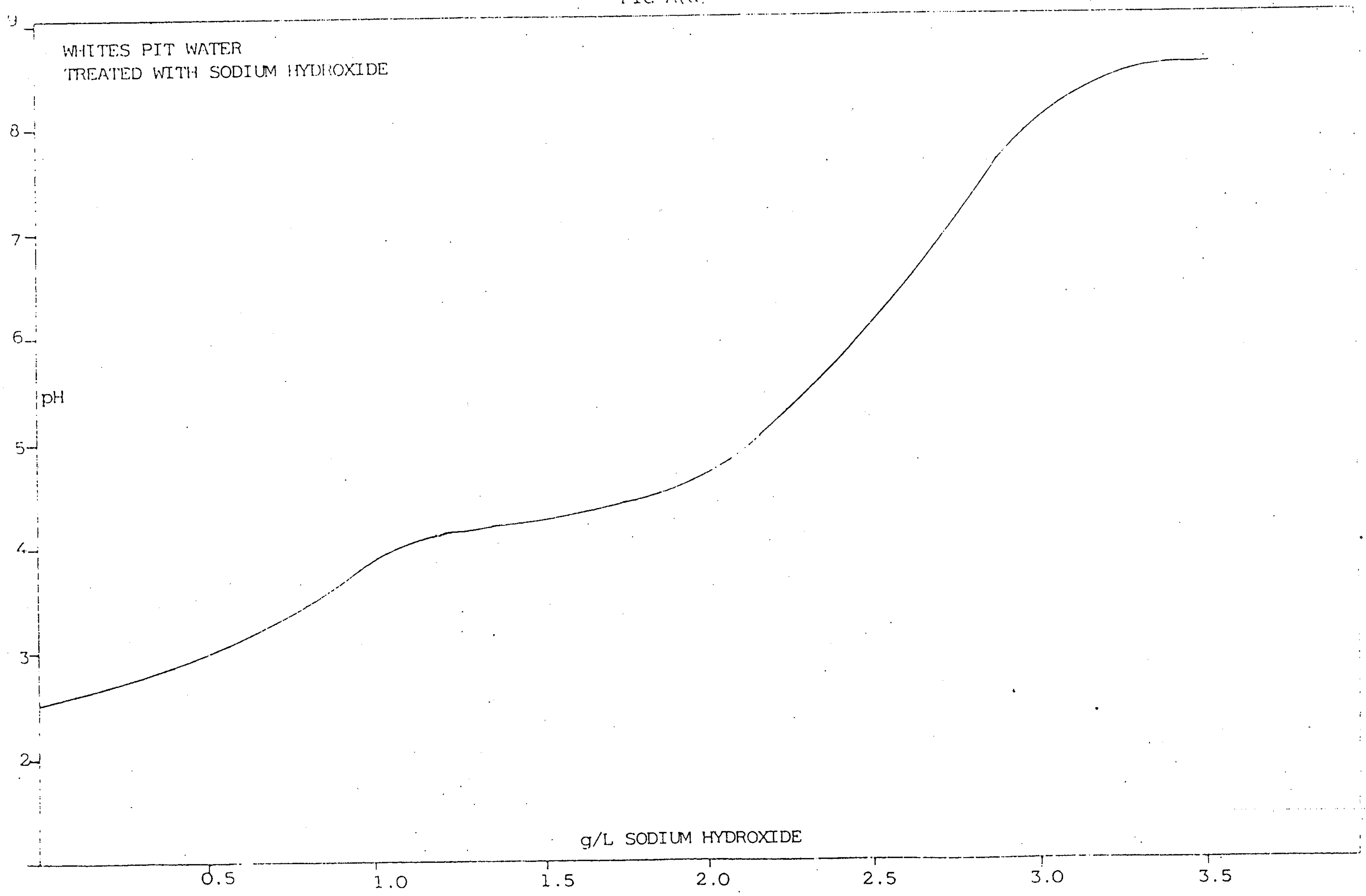

WHITES PIT WATER
TREATED WITH SODIUM HYDROXIDE
9
8
7
6
pH
5
4
3
2
g/L SODIUM HYDROXIDE
0.5
1.0
1.5
2.0
2.5
3.0
3.5

FIG A(b)

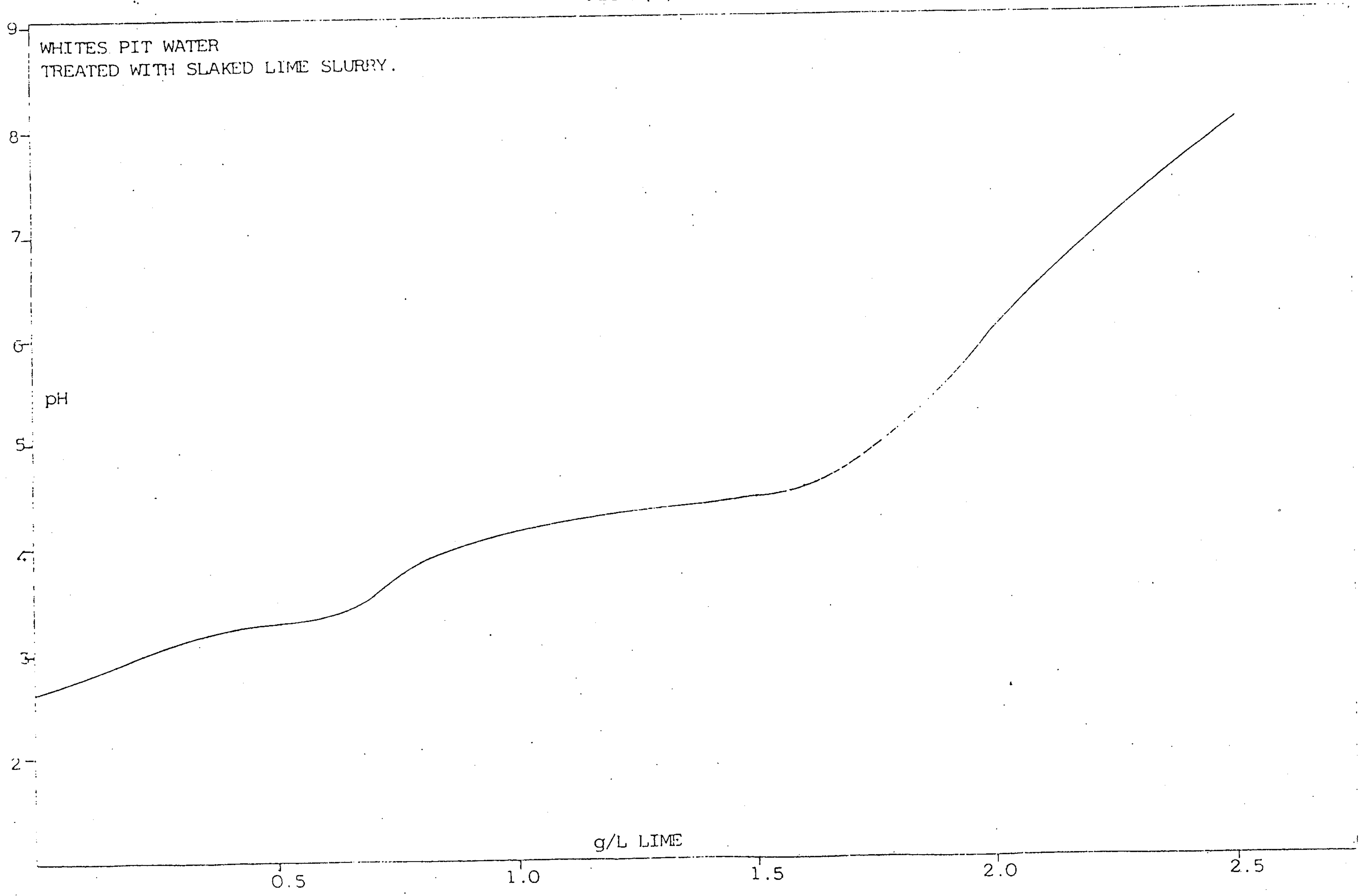
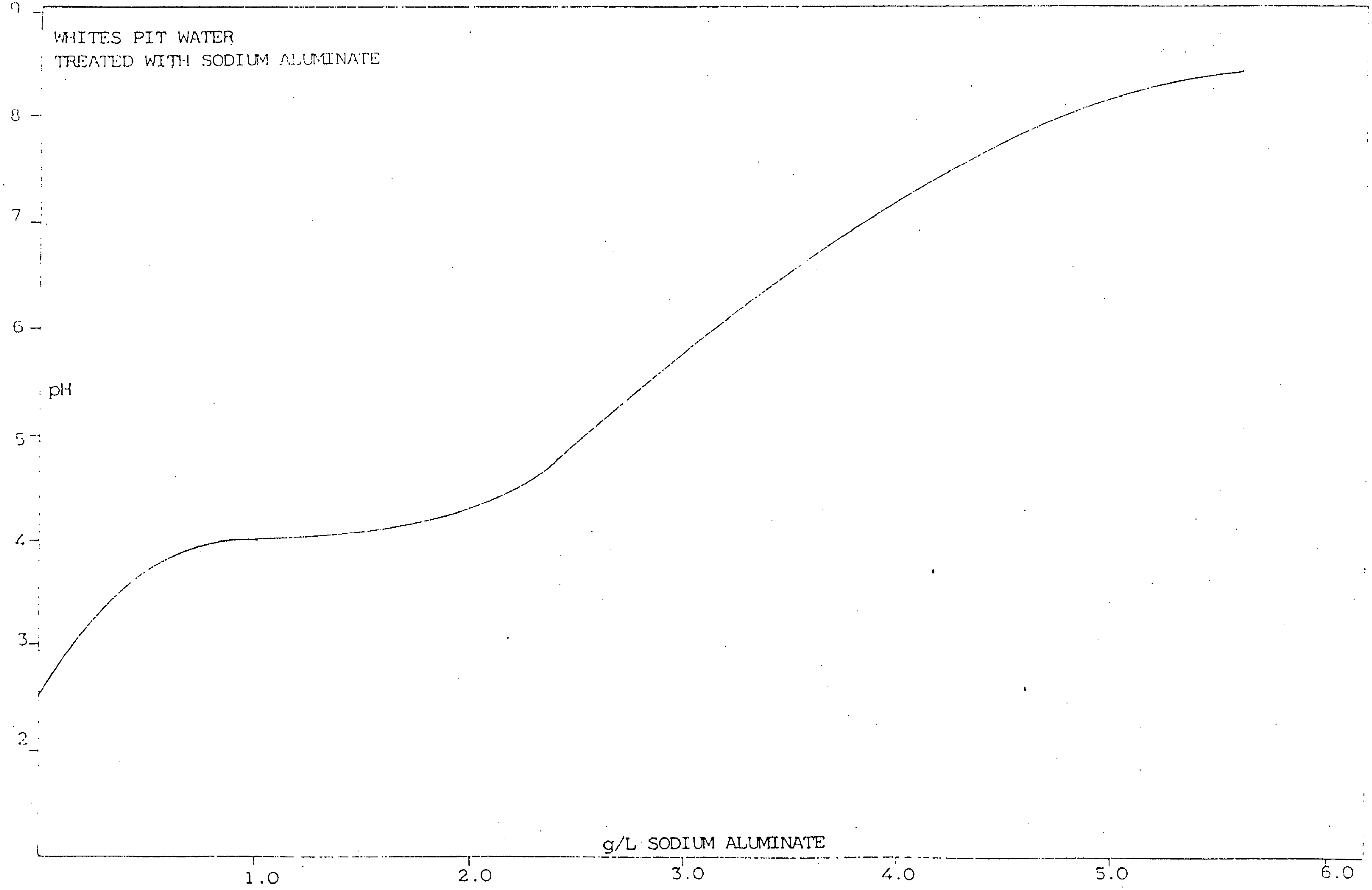

WHITES PIT WATER
TREATED WITH SLAKED LIME SLURRY.
pH
9
8
7
6
5
4
3
2
g/L LIME
0.5
1.0
1.5
2.0
2.5

FIG A(c)



WHITES PIT WATER
TREATED WITH SODIUM ALUMINATE
pH
9
8
7
6
5
4
3
2
g/L SODIUM ALUMINATE
1.0
2.0
3.0
4.0
5.0
6.0

FIG B(a)

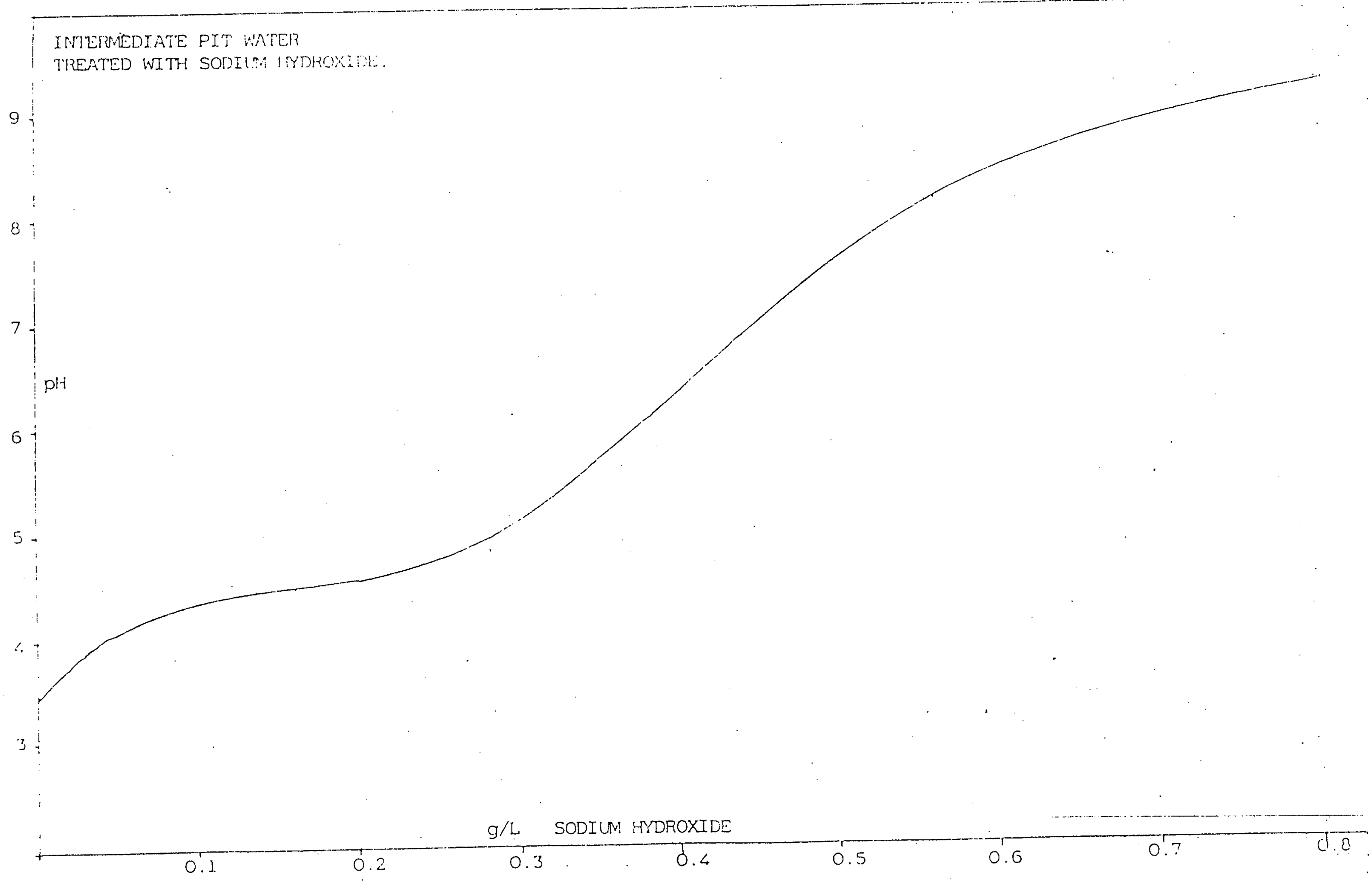

INTERMEDIATE PIT WATER
TREATED WITH SODIUM HYDROXIDE.
pH
9
8
7
6
5
4
3
g/L SODIUM HYDROXIDE
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

FIG B(b)

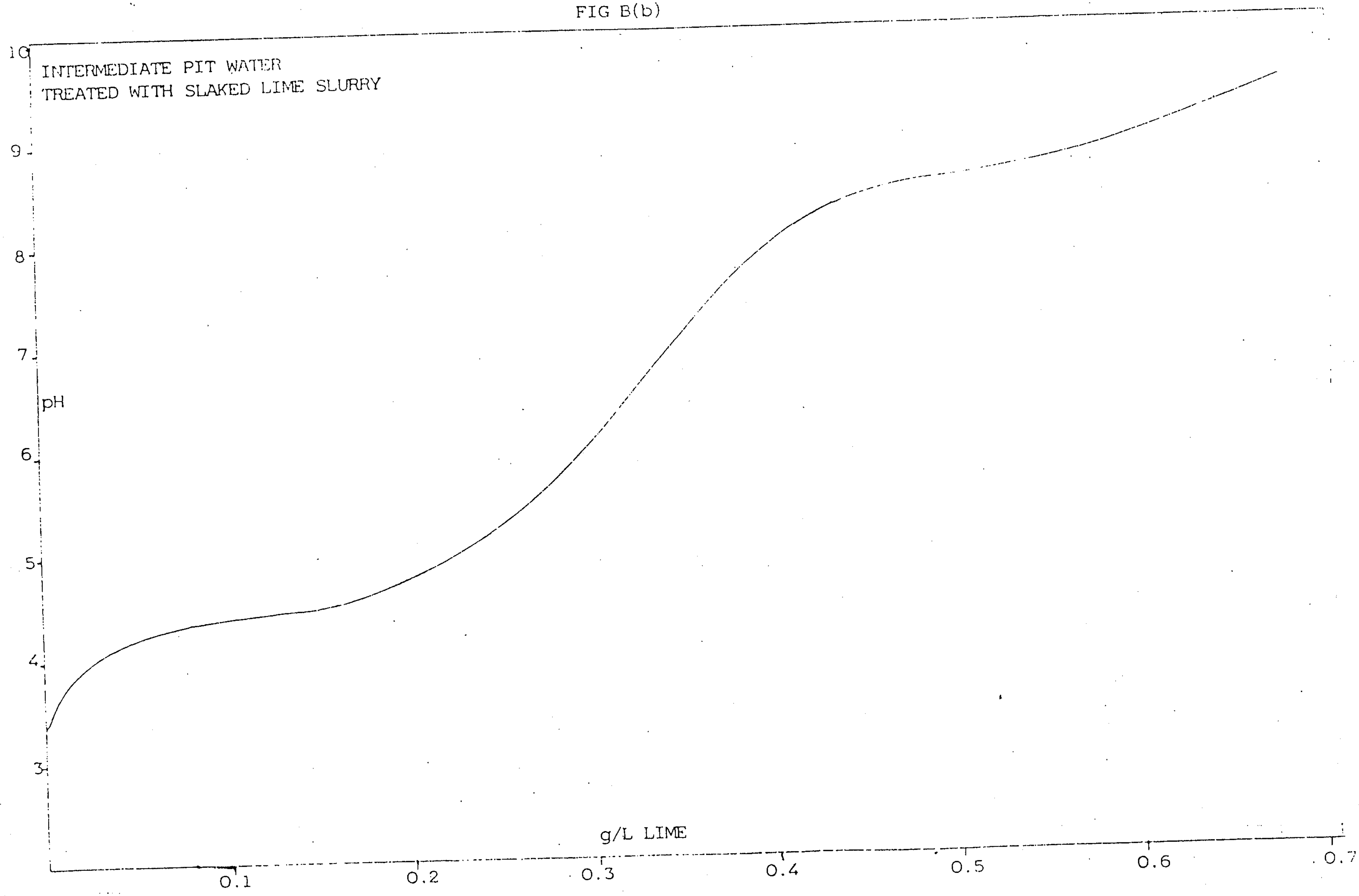
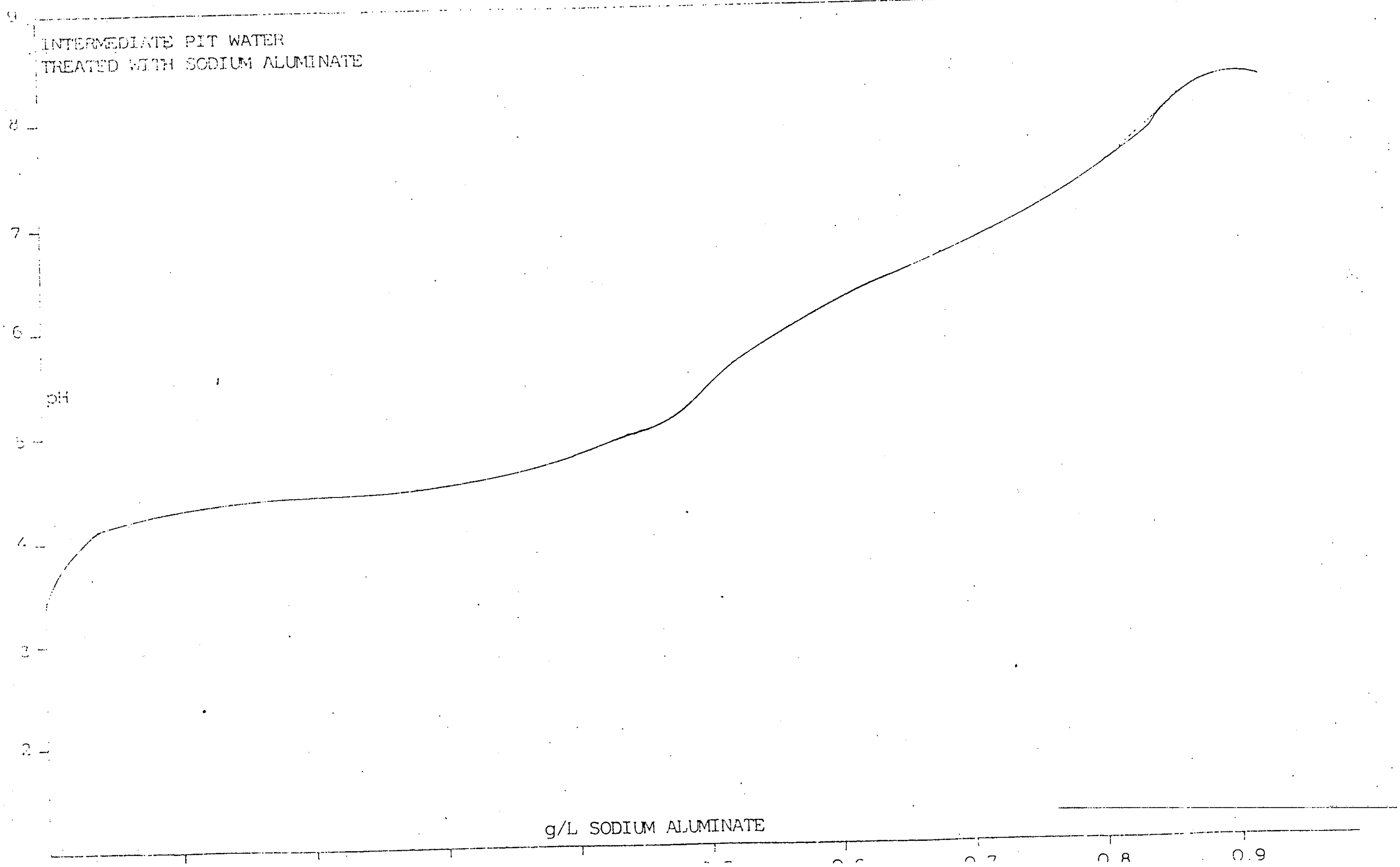

INTERMEDIATE PIT WATER
TREATED WITH SLAKED LIME SLURRY
pH
10
9
8
7
6
5
4
3
g/L LIME
0.1
0.2
0.3
0.4
0.5
0.6
0.7

FIG B(c)


INTERMEDIATE PIT WATER
TREATED WITH SODIUM ALUMINATE
pH
8
7
6
5
4
3
2
g/L SODIUM ALUMINATE
0.8
0.9

Technical reference to the Water Treatment Study:

APPENDIX 4

WATER SAMPLING AND ANALYSIS FOR INTERMEDIATE OPEN CUT, RUM JUNGLE 21 JULY 1981

AND

WATER SAMPLING AND FIELD ANALYSIS FOR WHITES OPEN CUT, RUM JUNGLE 8 SEPTEMBER 1981

BOTH BY:

THE NORTHERN TERRIROTY OF AUSTRALIA

DEPARTMENT OF TRANSPORT AND WORKS

4-28-15(2)
HW:LM

28 July, 1981

REPORT - WATER SAMPLING AND ANALYSIS FOR INTERMEDIATE OPENCUT, RUM JUNGLE, 21 JULY, 1981

Water sampling and field analysis were carried out by Chemists Holger Henkel and Hugh Wilson at Intermediate opencut at Rum Jungle for 2 hours from 10.30 am on 21 July 1981.

Jar tests and sub-sampling of water samples collected, were carried out at East Point Laboratory during the afternoon of 21 July 1981. Subsequently, chemical analysis of water samples collected at Intermediate opencut and sub-samples at East Point Laboratory were analysed for metals using flame A.A.S., and other conventional methods for additional parameters.

The field work was carried out using a NISKIN sampler of 6 litre capacity, and a MONTEDORO - WHITNEY MULTI-PARAMETER METER AND PROBE MARK IV, precalibrated in the laboratory.

Listed below are the results of these exercises:-

Jar tests at East Point Laboratory were carried out using a quick-lime/water suspension with a concentration of 10mg/ml added to 500 ml jars of water, and flocculated using a S E M, 6 paddle mixer with variable mixing speeds.

QUICKLIME ANALYSIS:- Lime calcined at 950c for 20 minutes.

Ca	= 62.7%
as CaO	= 87.7%
Mg	= 0.45%
as MgO	= 0.8%
Fe	= 0.34%
as Fe_2O_3	= 0.5%

METALS

Cu	= 0.005%
Pb	= 0.005%
Cu	= 0.005%
Mn	= 0.050%
Co	= 0.005%

WATER SAMPLE FROM 50 METRES DEPTH

JARS	1.	2.	3.	4.	5.	6.
Sample Volume in ml	500	500	500	500	500	500
Lime-ml	16.75	17.5	18.75	20	21.25	22.5
mg/L	335	350	375	400	425	450
pH after Flocculation	6.3	6.4	6.8	7.1	7.4	7.9

REMARKS:-

1. Heavy Floc was present in all jars.
2. After 5 minutes settling, the volume of Floc appeared to increase in jars from left to right.
3. Settled water from jar 4 above, was taken for metals analysis by A.A.S., and for analysis for other parameters.
4. Floc settled quickly in all jars. The supernatent water was essentially Floc free.

REMARKS:-

1. Heavy Orange/Red Floc in all samples.

2. The volume of Floc after 5 minutes settling appeared to increase from jars from left to right.

3. Settled water from jar 1 above, was taken for metals analysis by A.A.S., and for analysis for other parameters.

4. Floc settled quickly in all jars. The supernatent water was essentially Floc Free.

JAR TEST RESULTS

Quick-Lime/Water suspension added to 500 ml of sample water, mixed at 150 R.P.M. for 1 minute, Flocculated at 20 R.P.M. for 2 minutes, and allowed to settle for 5 minutes.

Sub-samples for metals analysis and other parameters were taken from jars of settled water as shown below.

WATER SAMPLE FROM 60 METRES DEPTH

JARS	1.	2.	3.	4.	5.	6.
Sampling Vol in mls.	500	500	500	500	500	500
Lime-ml	12.5	13.75	15.0	16.75	17.5	18.75
mg/L	250	275	300	335	350	375
pH after Flocculation.	5.8	6.2	6.4	6.8	7.0	7.4

REMARKS:-

1. Heavy orange/red Floc in all samples.
2. The volume of Floc after 5 minutes settling appeared to increase in jars from left to right.
3. Floc settles quickly in all jars. Within 5 minutes it was a heavy layer about 1.5 cm thick. The supernatent water was essentially Floc free.

JARS	1.	2.	3.	4.	5.	6.
Sample Vol in mls.	500	500	500	500	500	500
Lime-ml	17.5	18.75	20	21.25	22.5	23.75
mg/L	350	375	400	425	450	475
pH after Flocculation	7.1	7.0	7.1	7.5	7.7	8.0

SAMPLING AND FIELD ANALYSIS

Samples were collected at 60m, 50m, 25m, 2m.

Readings were taken at 50m, 45m, 40m, 35m, 30m, 25m, 20m, 15m, 10m, 5m, 2m, 1m.

RESULTS OF MONTEDORO-WHITNEY MULTI-PARAMENT METER MARK IV READINGS

Depth-Metres	50	45	40	35	30	25	20	15	10	5	2	
Conductivity (Microsiemens/Cm)	4210	4210	4110	4110	4110	4110	4110	4030	4040	4040	4050	40
Temperature	25.0	24.9	24.9	24.9	24.9	24.9	25.00	25.2	25.4	25.6	25.9	
pH	3.3	3.1	3.0	3.0	3.0	3.0	3.0	2.9	2.9	2.9	2.9	3
Dissolved Oxygen (mg/L)	1.5	1.3	1.4	1.5	1.5	1.6	1.8	5.3	6.1	6.8	7.0	8

WATER SAMPLE FROM 25 METRES DEPTH

JARS	1.	2.	3.	4.	5.	6.
Sample - Vol in ml	500	500	500	500	500	500
Lime - ml	16.5	17.5	18.75	20.0	21.25	22.5
mg/L	330	350	375	400	425	450
pH after Flocculation	6	6.2	6.6	6.8	7.1	7.4

REMARKS:-

1. There was quite a difference in the colour of Floc in this series of jar tests. - The Floc had a slight green colour.
2. The volume of Floc after 5 minutes settling, appeared to increase in jars from left to right.
3. Settled water from jar 1 above, was taken for metals analysis by A.A.S., and for analysis for other parameters.
4. Floc settled quickly in all jars. The supernatent water was essentially Floc free.

WATER SAMPLE FROM 2 METRE DEPTH

JAR	1.	2.	3.	4.	5.	6.
Sample Volume in ml	500	500	500	500	500	500
Lime - ml	16.75	17.5	18.75	20.00	21.25	22.5
mg/L	335	350	375	400	425	450
pH after Flocculation.	6.2	6.3	6.4	6.6	6.8	7.0

REMARKS:-

1. Heavy Floc of light rey/Green appearance was present in all jars.
2. After 5 minutes settling, the volume of Floc appeared to increase in jars from left to right.
3. Settled water from jar 5 above was taken for metals analysis by A.A.S., and for analysis for other parameters.
4. Floc settled quickly in all jars. The supernatent water was essentially Floc free.

WATER SAMPLE PREPARED FROM EQUAL VOLUMES OF SAMPLES TAKEN FROM 2, 25, 50, 60 METRES DEPTH

JAR	1.	2.	3.	4.	5.	6.
Sample Volume in ml	500	500	500	500	500	500
Lime-ml	16.75	17.5	18.75	20	21.25	22.5
mg/L	335	350	375	400	425	450
pH After locculation.	6.1	6.3	6.8	7.2	6.9	7.4

REMARKS:-

1. Heavy Floc appeared in all jars.
2. After 5 minutes settling, the volume of Floc appeared to increase in jars from left to right.
3. Settled water from jar 4 above was taken for metal analysis by A.A.S. and for analysis for other parameters.
4. Floc settled quickly in all jars. The supernatent water was essentially Floc free.

81/076 RUM JUNGLE INTERMEDIATE OPEN CUT

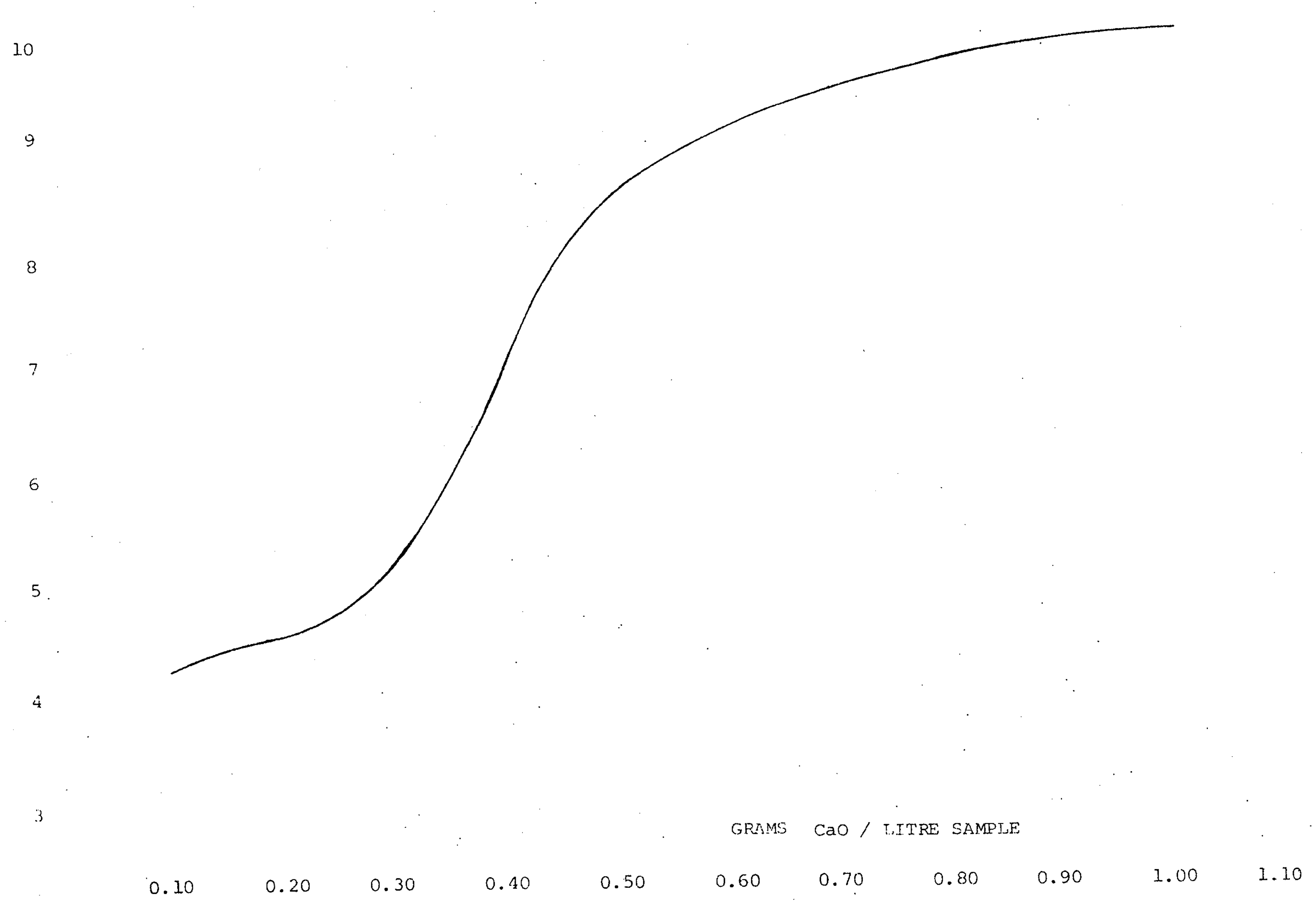
DEPTH 2M

pH ADJUSTED WITH Ca0 SUSPENSION

	COPPER Cu mg/l	LEAD Pl mg/l	MANGANESE Mn mg/l	NICKEL Ni mg/l	COBALT Co mg/l	ZINC Zn mg/l
pH 3.37 UNTREATED SAMPLE	72	0.2	64	14	15	7.1
pH 7.0	2.3	0.1	43	3.4	3.9	0.3
pH 8.0	1.3	$<$0.1	17.7	0.5	0.6	0.05
pH 9.0	$<$0.1	$<$0.1	0.22	$<$0.1	$<$0.1	0.05
pH 10.0	0.1	$<$0.1	$<$0.1	$<$0.1	$<$0.1	0.05

INTERMEDIATE OPEN CUT - RUM JUNGLE

2 METERS BELOW SURFACE



RUM JUNGLE INTERMEDIATE OPEN CUT
METAL ANALYSIS ON WATER SAMPLES
USING FLAME A.A.S.

R = Untreated Water
T = Lime treated Flocculated and settled Water

Water Samples depth in Metres	CALCIUM Ca		MAGNESIUM Mg		COPPER Cu		COBALT Co		LEAD Pb		MAGNGANESE Mn		IRON (in Sol) Fe		NICKEL Ni		ZINC Zn
	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.	T.	R.
2 Metres	157	382	422	398	72	2.3	15	3.9	0.2	0.1	64	43	1.2	0.1	14	3.4	7.1
25 Metres	166	367	434	398	67	0.9	15	5.1	<0.1	<0.1	65	42	1.2	0.1	14	4.8	7.3
50 Metres	178	380	463	435	56	0.4	15	3.1	<0.1	<0.1	66	44	4.0	0.4	14	3.1	9.1
60 Metres	209	374	547	426	36	0.2	16	2.6	<0.1	<0.1	67	49	5.7	0.4	15	2.8	10.1
Mixture of water from 2,25,50,60m depths		376		519		0.4		2.3		<0.1		39		0.4		2.5	

File: 4-28-15 (2)
HW:LM

18th September, 1981

REPORT:- WATER SAMPLING AND FIELD ANALYSIS FOR WHITE's OPENCUT, RUM JUNGLE, 8 SEPTEMBER, 1981.

Water samples were collected, and field analysis carried out by Chemists Holger Henkel and Hugh Wilson at White's opencut at Rum Jungle, for approx 2 hours from 10am, on 8 September, 1981. Samples were collected from a boat at about the centre of the lake.

Jar tests and sub-sampling of water samples collected, were carried out at East Point Laboratory during the afternoon of 8 September, and during 9 September, 1981. Subsequently, chemical analysis of water samples collected at White's opencut, and sub-samples at East Point Laboratory, were analysed from metals using flame A.A.S.and Carbon Rod, and other conventional methods were used for additional parameters.

The field work was carried out using a NISKIN sampler of 6 litre capacity, and a MONTEDORO - WHITNEY MULTI - PARAMETER METER AND PROBE MARK IV, precalibrated in the laboratory.

Listed below are the results of this exercise:-

Jar tests at East Point Laboratory were carried out using a quick-lime/water suspension with a concentration of 90 mg/ml added to 500 ml jars of water, and floculated using a S.E.M., 6 paddle mixer with variable mixing speeds.

QUICKLIME ANALYSIS :- lime calcined at 950c for 20 minutes.

	Ca	= 62.7%
as	CaO	= 87.7%
	Mg	= 0.45%
as	MgO	= 0.8 %
	Fe	= 0.34%
as	Fe_2O_3	= 0.5 %

METALS

Cu	= <0.005%
Pb	= <0.005%
Mn	= 0.050%
Co	= <0.005%

SAMPLING AND TESTING IN THE FIELD,
WHITE's OPENCUT - 8 SEPTEMBER, 1981 - 10am to 12.30pm

Samples were collected at 48 meters, 25 and 2 meter depths.
Readings were taken at 48m, 45m, 40m, 35m, 30m, 25m, 20m, 15m, 10m, 5m, 3m, 2m, 1m.

RESULTS OF MONTEDORO - WHITNEY MULTI - PARAMETER METER MARK IV READINGS.

DEPTH - METRES	48	45	40	35	30	25	20	15	10	5	3	2	1
CONDUCTIVITY (MIRCO-SIEMENS/cm)	7830	8700	9000	9000	9000	8980	8990	8980	8710	6820	6200	6200	6200
TEMPERATURE C	26.0	26.0	25.8	25.8	25.7	25.0	25.7	25.7	26.0	26.0	28.6	28.8	29.0
pH	2.8	2.8	2.6	2.6	2.6	2.6	2.6	2.8	2.7	2.9	2.9	3.1	3.[illegible]
DISSOLVED OXYGEN (mg/l)	0.9	1.1	0.8	0.7	0.7	0.7	0.7	0.6	0.5	0.9	7.0	7.6	7.6

LAB No 81/1482-81/1486

WHITES OPEN CUT 8/9/81
45 METERS

SHEET 1 of 2

pH	2.8	6.0	7.0	8.1	9.0
CONDUCTIVITY	8700	–	–	–	–
GRAMS/LITRE LIME	–	2.1	2.7	3.2	3.9
Ca mg/l	560	860	790	950	1300
Mg mg/l	1000	850	700	540	240
TOTAL HARDNESS ($CaCO_3$)	5800	5600	4800	4500	4200
SULPHATE SO_4	7700	5300	4700	4500	3300

HEAVY METALS

COPPER Cu mg/l	57	0.4	<0.05	0.05	0.05
LEAD Pb mg/l	0.3	0.2	<0.1	<0.1	<0.1
MANGANESE Mn mg/l	180	150	60	18	2.4
NICKEL Ni mg/l	12.4	3.2	0.1	<0.1	<0.1
ZINC Zn mg/l	5.8	0.2	<0.05	<0.05	<0.05
IRON IN SOLUTION mg/l	390	45	0.5	<0.1	<0.1
COBALT CO mg/l	13.5	3.5	0.1	<0.1	<0.1

B No

FLOC TESTS

ITES OPEN CUT 8/9/81 45 METERS

0 mls SAMPLE IN 1 LITRE "LOW FORM" BEAKER

EET 2 of 2

ST NO	G/L LIME	pH	COLOUR	FLOC VOLUME	REMARKS
1	1.68	5.16	LIGHT BROWN	190 mls	SUPERNATANT DID NOT CLEAR, SAMPLE WAS TURBID TO START WITH.
2 /1483	2.18	5.96	GREENISH	300 mls	SAMPLE CHEMICALLY ANALYSED
3.	2.52	6.70	"	300 mls	AS SAMPLE 1
4 /1484	2.70	7.1	GREEN/GREY	325	SAMPLE CHEMICALLY ANALYSED
5	2.88	7.6	"	350	
6 /1485	3.24	8.1	"	480	SAMPLE CHEMICALLY ANALYSED
7	3.60	8.79	"	490	
8 1/1486	3.96	8.96	"	500	SAMPLE CHEMICALLY ANALYSED ALSO DID NOT SETTLE DURING FLOC TEST.

LAB No 1476-1481

JAR FLOC TESTS

WHITES OPEN CUT 25 METERS 8/9/81

SAMPLE VOL 500 mls IN 1 LITRE "LOW FORM" BEAKER

TEST No	G/L Lime	pH	COLOUR	FLOC VOLUME	REMARKS
1	2.16	5.7	GREEN/GREY	200 mls	
2 31, .78	2.43	6.2	"	200 mls	SAMPLE ANALYSED CHEMICALLY
3 31/1479	2.70	6.8	"	250 mls	SAMPLE ANALYSED CHEMICALLY
4 31/1480	3.24	8.0	"	300 mls	SAMPLE ANALYSED CHEMICALLY
5	3.60	8.4	"	350 mls	
6 31/1481	3.96	8.7	"	360 mls	SAMPLE ANALYSED CHEMICALLY

LAB No 81/1077-81/1481

WHITES OPEN CUT 8/9/81
25 METERS

SHEET 1 of 2

pH	2.6	6.0	6.8	8.0	8.7
CONDUCTIVITY	9000	-	-	-	-
GRAMS/LITRE LIME	-	2.4	2.7	3.2	3.9
CALCIUM Ca mg/l	575	830	810	940	1000
MAGNESIUM Mg mg/l	930	780	740	640	340
TOTAL HARDNESS ($CaCO_3$)	5200	5300	5000	5000	3900
SULPHATE SO_4	7500	4400	5000	3800	3500

COPPER Cu mg/l	56	0.1	< 0.05	< 0.05	< 0.05
LEAD Pb mg/l	0.3	0.3	0.1	0.1	0.1
MANGANESE Mn mg/l	180	130	100	20	4.6
NICKEL Ni mg/l	12.1	1.0	0.3	< 0.1	< 0.1
ZINC Zn mg/l	5.6	0.05	0.05	< 0.05	< 0.05
IRON (in solution) Fe mg/l	370	7.9	1.8	< 0.1	< 0.1
COBALT Co mg/l	13.5	1.2	0.5	0.1	0.1

81/1472-81/1476

WHITES OPEN CUT 8/9/81
2 METERS

pH	3.1	5.9	7.2	8.3	9.25
CONDUCTIVITY	6200	-	-	-	-
GRAMS/LITRE LIME	-	1.1	1.4	1.8	2.4
CALCIUM Ca mg/l	390	1000	1040	-	1145
MAGNESIUM Mg mg/l	780	730	640	-	230
TOTAL HARDNESS ($CaCO_3$)	4200	5500	5200	-	3800
SULPHATE SO_4	4800	4300	4800	-	3100

COPPER Cu mg/l	58	0.4	< 0.05	-	< 0.05
LEAD Pb mg/l	< 0.1	< 0.1	< 0.1	-	< 0.1
MANGANESE Mn mg/l	105	69	25	-	0.25
NICKEL Ni mg/l	9.5	3.8	0.1	-	< 0.1
ZINC Zn mg/l	6.5	0.4	< 0.05	-	< 0.05
IRON Fe mg/l	114	0.2	< 0.1	-	< 0.1
COBALT Co mg/l	11.5	3.8	0.2	-	< 0.1

LAB No 1473-1476

JAR FLOC TESTS

WHITES OPEN CUT 2 METERS

SAMPLE VOL 500 mls IN 1 LITRE "LOW FORM" BEAKER

SHEET 2 of 2

TEST No	G/L LIME	pH	COLOUR	FLOC VOLUME	REMARKS
1	0.36	4.14	ORANGE/RED	<100	DID NOT CLEAR
	0.72	4.57	"	100	" " "
3	0.90	5.40	"	150	SLIGHTLY CLOUDY
4 81/1473	1.08	5.93	"	200	SAMPLE CHEMICALLY ANALYSED SUPERNATANT CLEAR
5 81/1474	1.44	7.2	"	300	SAMPLE CHEMICALLY ANALYSED SUPERNATANT CLEAR
6 81/1475	1.80	8.3	"	350	SAMPLE CHEMICALLY ANALYSED FLOC SLOW TO SETTLE
7 81/1476	2.43	9.3	"	-	AS No. 6

LAB No 81/1487-81/1491

WHITES OPEN CUT 8/9/81
COMPOSITE

SHEET 1 of 2

pH	2.62	6.19	7.3	8.00	9.12
CONDUCTIVITY	8750	-	-	-	-
GRAM/LITRE LIME	-	1.8	2.3	2.7	3.6
CALCIUM Ca	480	1420	1800	1800	1700
MAGNESIUM Mg	820	780	630	500	160
TOTAL HARDNESS	4500	5000	7100	6500	4900
SULPHATE SO_4	6600	4400	4100	3600	2700

COPPER Cu	55	0.2	<0.05	<0.05	<0.05
LEAD Pb	0.3	<0.1	<0.1	<0.1	<0.1
MANGANESE Mn	160	110	26	7.8	0.6
NICKEL Ni	11.0	1.6	0.1	<0.1	<0.1
ZINC Zn	6.0	0.1	<0.05	<0.05	<0.05
IRON Fe (in solution)	322	6.3	<0.1	<0.1	<0.1
COBALT Co	12.6	1.5	0.2	0.1	<0.1

Technical reference to the Water Treatment Study:

APPENDIX 5

ANALYTICAL RESULTS FOR WATER TREATMENT TESTS REQUESTED BY THE STUDY CONSULTANT

ANALYTICAL RESULTS

FOR

WATER TREATMENT TESTS

REQUESTED BY M.P.E.S.

TABLE OF CONTENTS

NOTES ON TREATMENT OF WATER FROM WHITES OPEN CUT

The following is a compilation of graphs for a set of tests requested by M.P.E.S. Some deviation or extrapolation of test procedure has occurred including:-

- No sample was taken for analysis in the dolomite reactivity test at the 5 minute interval because no significant change in pH occurred.
- Essentially temperatures remained constant, throughout the reactivity test, hence aren't recorded.
- Sampling continued in the reactivity test until no significant change in pH occurred.
- Results for metal analysis below 10mg/L are recorded to the nearest 0.1mg/L, above 10mg/L to the nearest 1mg/L. Calcium and Sulphate results are recorded to the nearest 20mg/L.
- Alkali reactant added as a liquid slurry.
- Only 900ml of sample water was used, hence the changed dosage rate.
- At completion of experiment all beakers contained white precipitate. (Presumable Calcium Sulphate precipitated overnight). Also some precipitation occurred in the filtrate before analysis was completed.
- Average height of solution was 11.5cm and average diameter of beaker was 11.2cm.
- Lime freshly calcined before tests.

In the settling test observation began after 1 minutes stirring and the following observations noted:-

- 0.55gm/L and 1.11gm/L Lime tests had an ill defined interface for most of the experiment, with a light flock diffused throughout most of the beaker. (Thermal effects)
- 2.22gm/L Lime test had a good flock and well defined interface.
- Unreacted alkali was left on completion of the experiment in the 3.3, 4.4 and 6.6gm/L Limestone test and also 2.22gm/L Lime test.
- Only one graph of time versus interface had enough observation to merit drawing.

(G. JOHNSTON)

(J. ALCOCK)
East Point Laboratory

TEST PROGRAM

The following tests are to be performed in the order indicated:

1. Reaction Rate Tests

   1.1 Using Dolomite — Mg CO_3

   Use commercial grade agricultural dolomite ground to a fine powder -200
   (Perform sizing on ground material and use same material for all tests)

   Use addition rates of 3.0 4.0 6.0 10.0 gms/litre dolomite

   1.2 Using Calcium Carbonate — Ca CO_3

   Use ground limestone ground to 100% -200 #
   (perform sizing) 4.0 gms/litre.

   1.3 Using Lime — Ca O

   Use lime (slurried in 20 ccs of water) at the following addition rates 0.5, 1.0, 2.0 4.0 gms/litre.

2. Settling Tests

   Following an assessment of the results of the reactivity tests, settling tests should be performed using lime additions of 0.5, 1.0, 2.0, and 4.0 gms/litre.

   I have not ruled out the possibility of using dolomite, but I suspect that it will be inferior to lime and therefore settling tests are to be performed only if results are unexpectedly encouraging.

   Settling tests should be performed using limestone CaO additions of 3.0, 4.0 and 6.0 grams/litre.

3. General

   In all tests adequate analyses of reactants is required. Sizings must be performed on limestone and dolomite. Lime used must be titrated for % available CaO, as at times lime has been partially slaked by exposure to atmospheric moisture.

4. Settling Tests - Procedures

Settling tests are to be conducted in the following manner:

Aim : To measure the settling characteristics of flocculated material following lime (alkali) additions to polluted water.

Apparatus :
- 1000 mill measuring cylinders
- Electric Stirrer
- Stop Clock
- Scale (in cms)
- pH Meter
- Miscellaneous beakers
- Balance
- Drying Oven

Procedure:

(1) Weigh out required amount of alkali to be added (see table)

(2) Fill 1000 mil measuring cylinder with polluted water (measure pH)

(3) Place in stirrer cylinder and commence stirring.

(4) Add alkali and start stop watch.

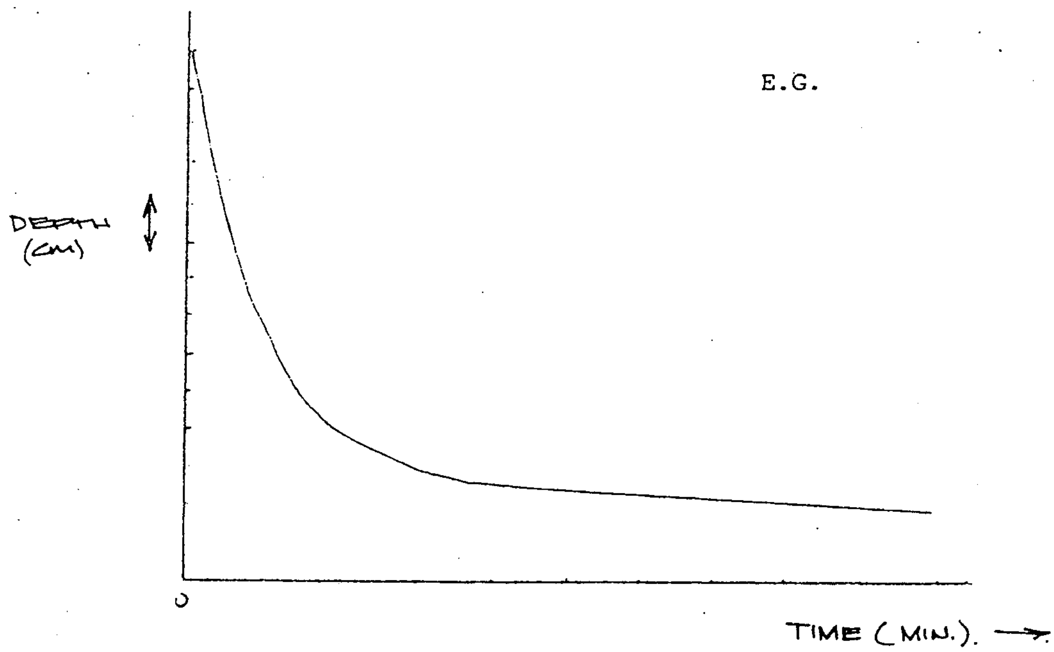
(5) Record level of interface at the following intervals 1, 2, 3, 4, 5, 10, 20, 60 minutes and 2, 4, 6, 8, 16, 24 hours.
(This will enable compression data to be developed)

(6) Filter and dry at 105°c.

Calculations and Plotting of Results:

Plot Depth versus time of interface

E.G.



Calculate final pulp Density

(1) Volume of Settled Pulp = V
Weight of Dried Solids = Wi
(assume density solids = 2.6)
Pulp Density = $\frac{Wi}{V}$ x 100% =

5. REACTIVITY TEST PROCEDURE

Reactivity tests are to be performed as below :

Aim: The aim of this test is to determine the rate at which a given amount of alkali changes the ph (and heavy metal drop out) of polluted water.

Apparatus: Beakers
Stirrer
pH Meter
Filter
Buchner funnel
Stop clock
Drying oven

Procedure:

(1) Measure out 1 litre of water.

(2) Record pH, temperature (leave pH meter in pulp)

(3) Set up stirrer on dummy sample and ensure agitation is sufficient to fully disperse reactant that is to be added to pulp. Record Speed and stirrer type, and use this set up for all reactivity tests.

(4) Set stirrer going and add reactant to beaker
Set time at c = 0

(5) Record pH at minute intervals on times appropriate to rate of change.

(6) Draw off samples of pulp and filter at 1, 5, 10, 30 60 minute intervals and analyse filtrate from heavy metal ions.

(7) When pH has stabilised draw off pulp sample and filter, and analyse for pH, Ca 0, SO_4 and heavy metals.
Dry at 105°c residue and analyse for heavy metals.

Results : Plot pH, heavy metal concentrations versus time.

WHITES OPEN CUT, SAMPLE
2 METERS FROM THE SURFACE,
TREATED WITH 11.1 grm/l of
DOLOMITIC LIME.

Time since addition of Alkali (Min)	0.0	1.0	5.0	10.0	20.0	30.0	80.0
pH	2.8	4.6	4.6	4.8	5.0	5.1	5.6
Temp °C							
Calcium, Ca mg/L	280	580		540	620	600	660
Iron, Fe mg/L	82	1.3		1.1	1.2	0.9	< 0.5
Copper, Cu mg/L	46	38		34	28	15	3.0
Manganese, Mn mg/L	70	71		71	70	69	69
Sulphate, SO_4 mg/L	4760	3720		4360	4360	4440	4360

WHITES OPEN CUT, SAMPLE
2 METERS FROM THE SURFACE,
TREATED WITH 4.44 gm/L OF
CALCIUM CARBONATE

Time since addition of Alkali (Min)	0.0	1.0	5.0	15.0	30.0	90.0
pH	2.8	5.4	5.7	5.9	6.1	6.5
Temp °C	21.8	22.8	22.8			
Calcium, Ca mg/L	280	740	800	760	800	760
Iron, Fe mg/L	82	0.9	1.2	0.9	<0.5	<0.5
Copper, Cu mg/L	46	20	19	14	8.3	1.7
Manganese, Mn mg/L	70	73	72	70	72	72
Sulphate, SO_4 mg/L	4760	4440	4600	4360	4530	4530

WHITES OPEN CUT, SAMPLE
2 METERS FROM THE SURFACE,
TREATED WITH 0.55 gm/L OF
CALCIUM OXIDE (LIME)

Time since addition of Alkali (Min)	0.0	1.0	5.0	15.0	60.0	120.0
pH	2.8	4.5	4.5	4.6	4.5	4.5
Temp °C	23					
Calcium, Ca mg/L	280	600	620	620	620	
Iron, Fe mg/L	82	1.2	0.7	0.5	0.5	
Copper, Cu mg/L	46	38	39	40	41	
Manganese, Mn mg/L	70	71	70	71	72	
Sulphate, SO_4 mg/L	4760	4440	4440	4440	4920	

WHITES OPEN CUT, SAMPLE
2 METERS FROM THE SURFACE,
TREATED WITH 1.11grms/l OF
CALCIUM OXIDE (LIME)

Time since addition of Alkali (Min)	0.0	1.0	5.0	40 .0	60.0	120.0	180.0
pH	2.8	4.0	4.6	6.0	6.7	7.5	7.7
Temp °C	22	23.2					
Calcium, Ca mg/L	280	660	660	700	700	740	
Iron, Fe mg/L	82	5.0	0.5	$<$0.5	$<$ 0.5	$<$0.5	
Copper, Cu mg/L	46	27	22	0.8	0.3	0.1	
Manganese, Mn mg/L	70	61	55	45	42	34	
Sulphate, SO_4 mg/L	4760	4530	4360	4360	4200	4200	

WHITES OPEN CUT, SAMPLE
2 METERS FROM THE SURFACE,
TREATED WITH 2.22gm/L CALCIUM
OXIDE (LIME)

Time since addition of Alkali (Min)	0.0	3.0	5.0	10.0	30.0	60.0
pH	2.8	8.8	9.4	9.6	10.0	10.1
Temp °C	22	24.8				
Calcium, Ca mg/L	280	1100	1020	880	960	1100
Iron, Fe mg/L	82	$<$ 0.5	$<$ 0.5	$<$ 0.5	$<$ 0.5	$<$ 0.5
Copper, Cu mg/L	46	$<$ 0.1	$<$ 0.1	$<$ 0.1	$<$ 0.1	$<$ 0.1
Manganese, Mn mg/L	70	5.6	2.1	$<$ 1.0	$<$ 1.0	$<$ 1.0
Sulphate, SO_4 mg/L	4760	3560	3160	2700	1980	1980

WHITES OPEN CUT SAMPLE
2 METERS FROM THE SURFACE
TREATED WITH 3.33 gm/L LIMESTONE ($CaCo_3$)

Time Since addition of Alkali (in Min)	1.0	2.0	3.0	5.0	10.0	20.0	71.0	360.0	1230.00
Depth of Clear Soln. (cm)				0.3					10.7

Pulp Density $\frac{\text{(dry weight)}}{\text{(pulp Volume)}}$ = Q.023 grm/cm^3

WHITES OPEN CUT SAMPLE
2 METERS FROM THE SURFACE
TREATED WITH 4.44 grm/L LIMESTONE ($CaCo_3$)

Time Since addition of Alkali (in Min)	1.0	2.0	3.0	5.0	10.0	20.0	71.0	360.0	1230.00
Depth of Clear Soln. (cm)		0.3	0.3	0.3					10.7

Pulp Density
(dry weight) = **0.041** grm/cm^3
(pulp Volume)

WHITES OPEN CUT SAMPLE
2 METERS FROM THE SURFACE
TREATED WITH 6.66 grm/L LIMESTONE ($CaCo_3$)

Time Since addition of Alkali (in Min)	1.0	2.0	3.0	5.0	10.0	20.0	71.0	360.0	1230.00
Depth of Clear Soln. (cm)	0.2	0.3	0.4	0.3					10.9

Pulp Density
(dry weight) = 0.067 grm/cm^3
(pulp Volume)

WHITES OPEN CUT SAMPLE
2 METERS FROM THE SURFACE
TREATED WITH 0.55 gm/l LIME (CaO)

Time Since addition of Alkali (in Min)	1.0	2.0	3.0	5.0	10.0	20.0	71.0	360.0	1230.00
Depth of Clear Soln. (cm)						0.3	0.3		10.9

Pulp Density $\left(\frac{\text{dry weight}}{\text{pulp Volume}}\right) = 0.018\ \text{grm/cm}^3$

WHITES OPEN CUT SAMPLE
2 METERS FROM THE SURFACE
TREATED WITH 1.11 gm/L LIME (CaO)

Time Since addition of Alkali (in Min)	1.0	2.0	3.0	5.0	10.0	20.0	71.0	360.0	1230.00
Depth of Clear Soln. (cm)				0.2	0.3	0.3	0.3		10.5

Pulp Density $\left(\frac{\text{dry weight}}{\text{pulp Volume}}\right)$ = 0.012 gm/cm^3

WHITES OPEN CUT SAMPLE
2 METERS FROM THE SURFACE
TREATED WITH 2.22 gm/L LIME (CaO)

Time Since addition of Alkali (in Min)	1.0	2.0	3.0	5.0	10.0	20.0	71.0	360.0	1230.00
Depth of Clear Soln. (cm)	0.6	1.5	1.8	3.7	5.2	7.0	8.4	8.4	7.7

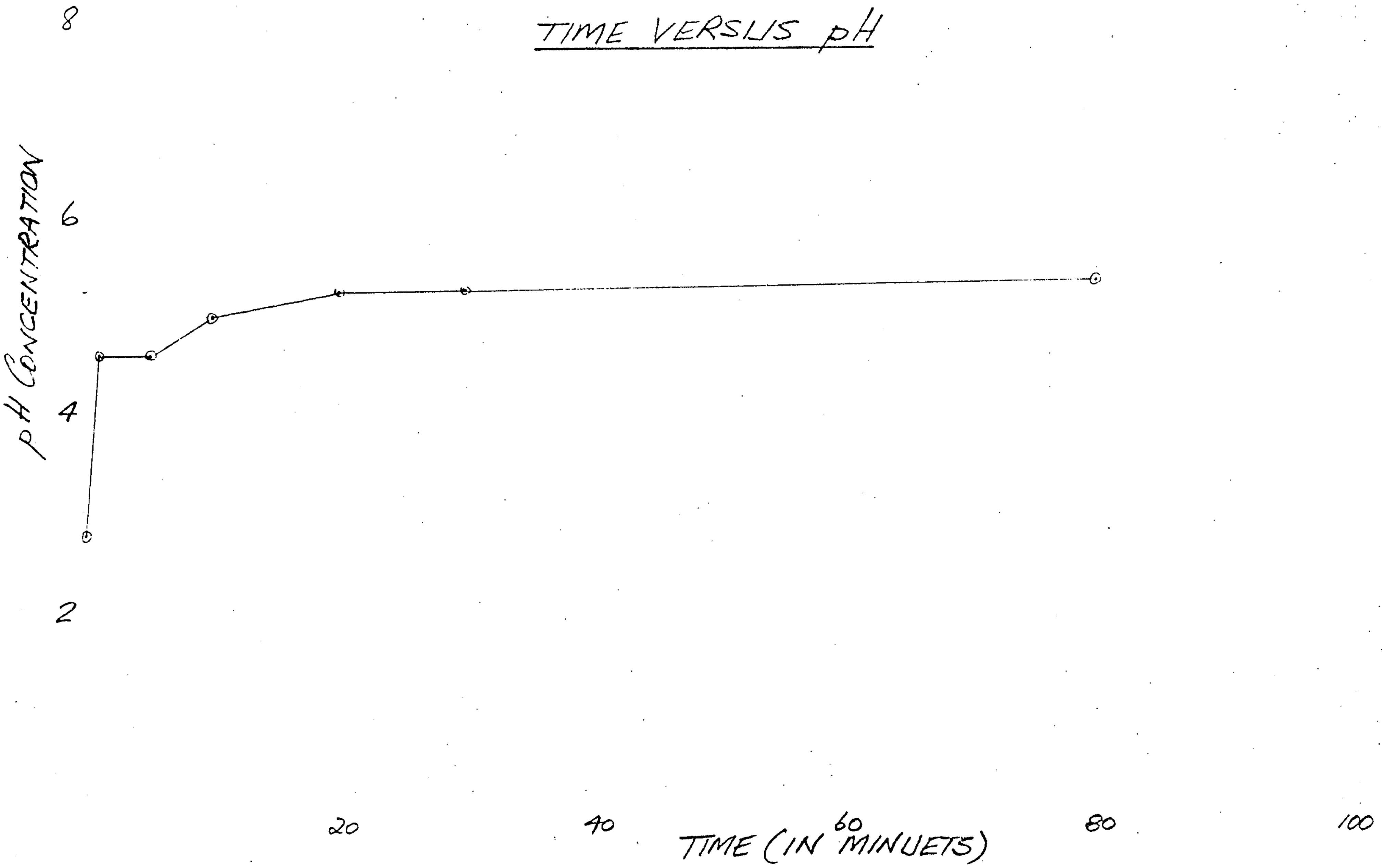
Pulp Density $\left(\frac{\text{dry weight}}{\text{pulp Volume}}\right) = 0.0064\ \text{grm/cm}^3$

WHITES OPEN CUT

SAMPLE TAKEN 2 metres FROM THE SURFACE

TREATED WITH 11·1 gms DOLOMITE LIME

TIME VERSUS pH

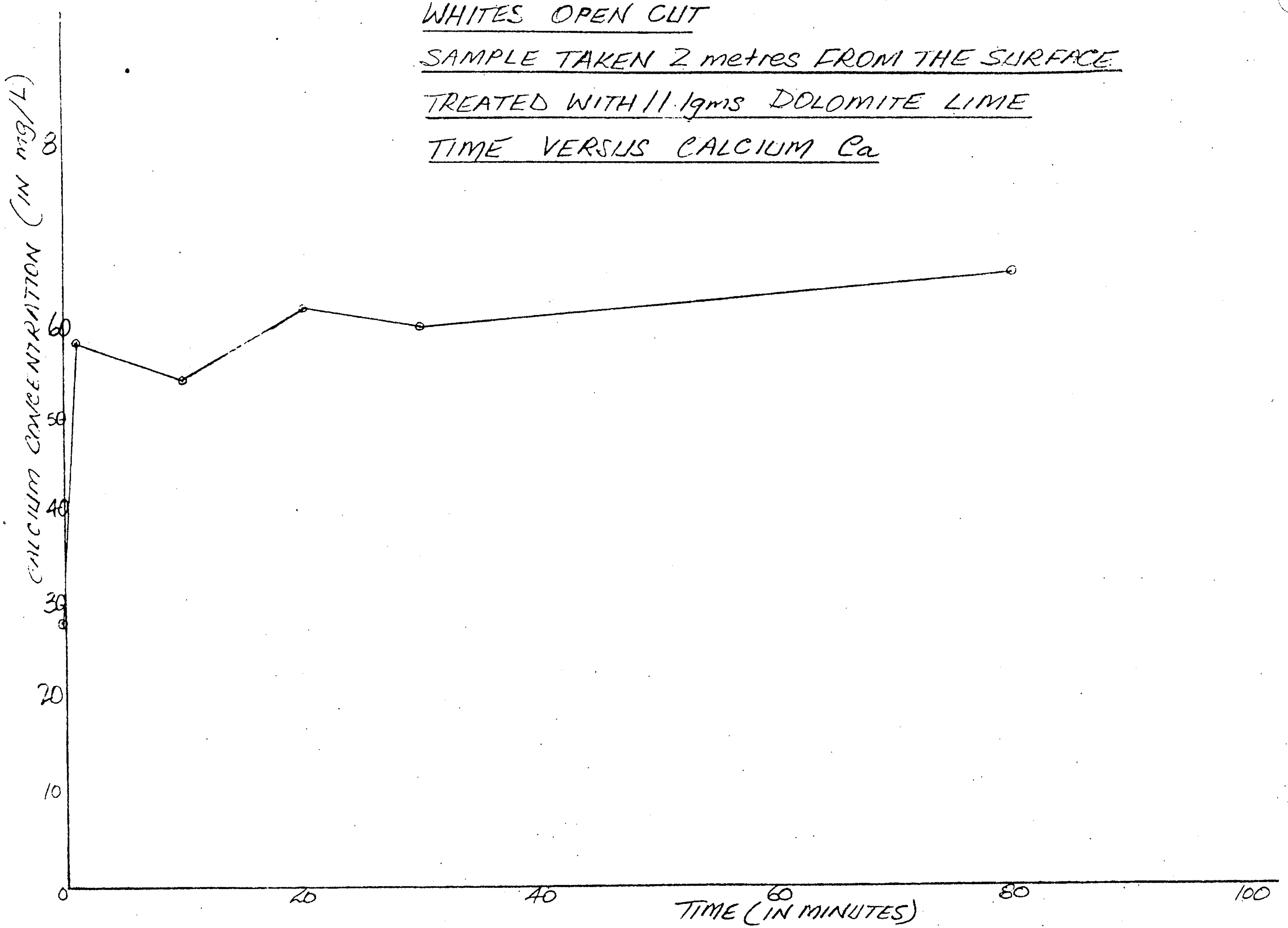


WHITES OPEN CUT

SAMPLE TAKEN 2 metres FROM THE SURFACE

TREATED WITH 11.1gms DOLOMITE LIME

TIME VERSUS CALCIUM Ca

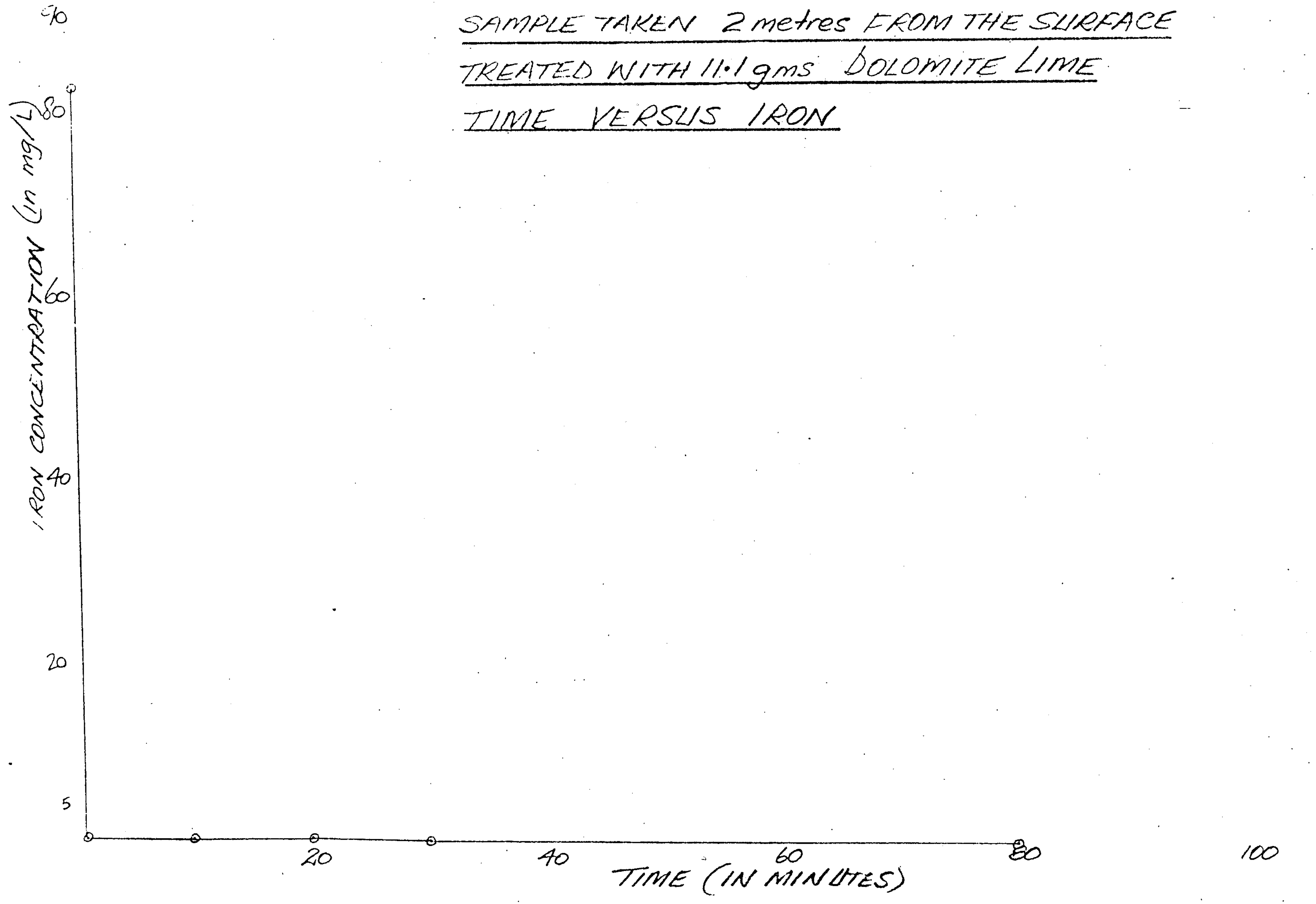


WHITES OPEN CUT

SAMPLE TAKEN 2 metres FROM THE SURFACE

TREATED WITH 11·1 gms DOLOMITE LIME

TIME VERSUS IRON

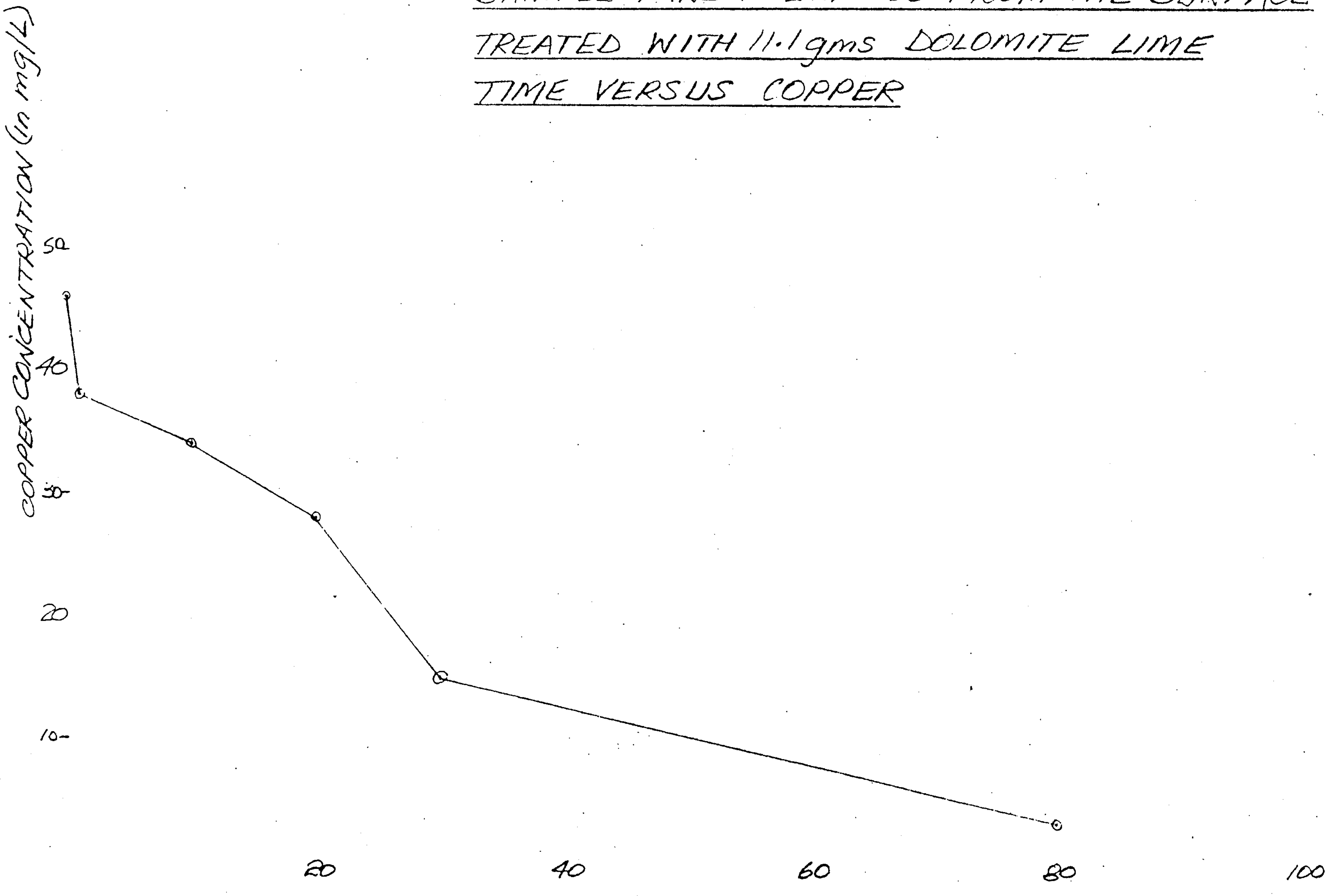


WHITES OPEN CUT

SAMPLE TAKEN 2metres FROM THE SURFACE

TREATED WITH 11·1gms DOLOMITE LIME

TIME VERSUS COPPER

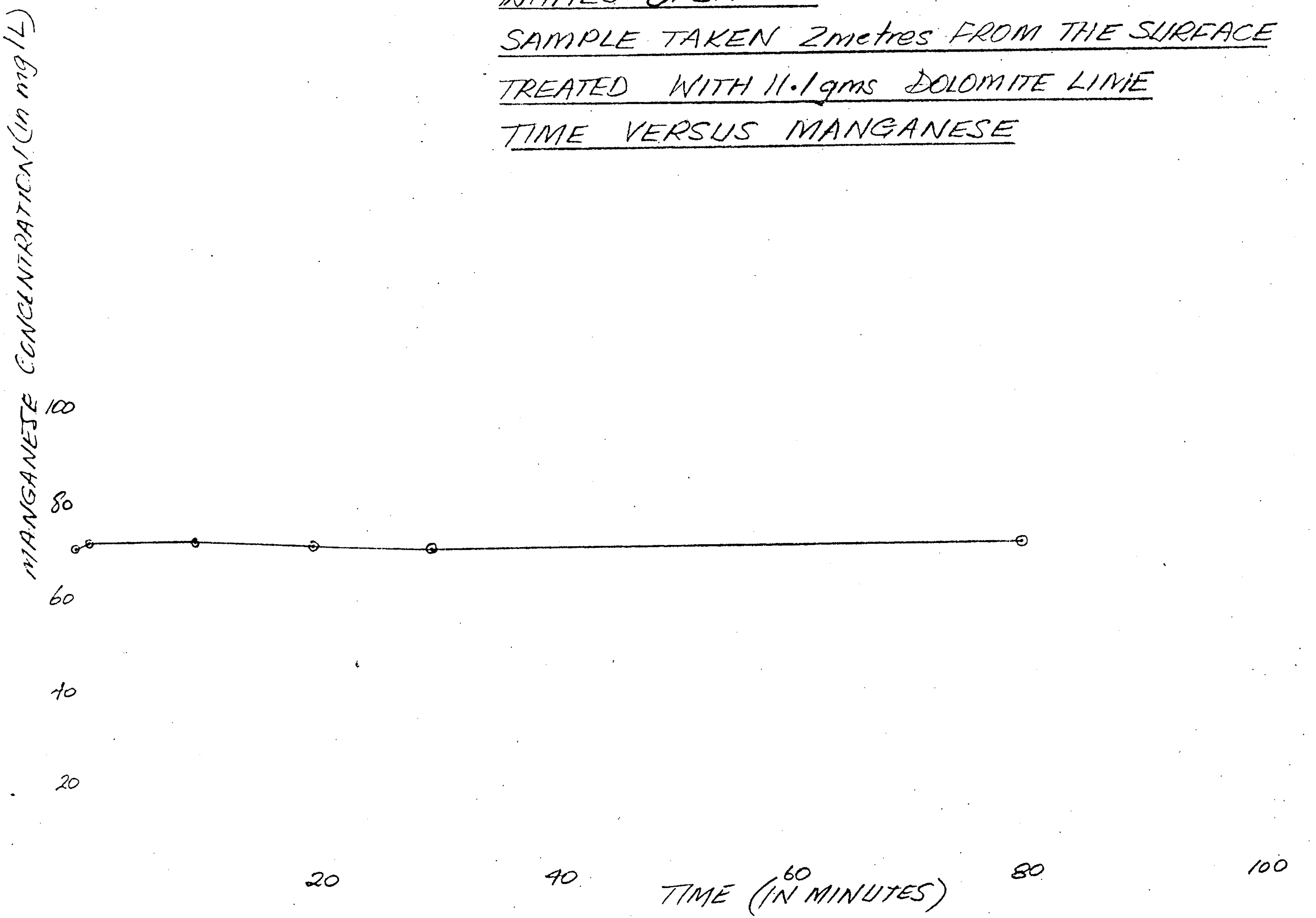


WHITES OPEN CUT

SAMPLE TAKEN 2metres FROM THE SURFACE

TREATED WITH 11.1gms DOLOMITE LIME

TIME VERSUS MANGANESE

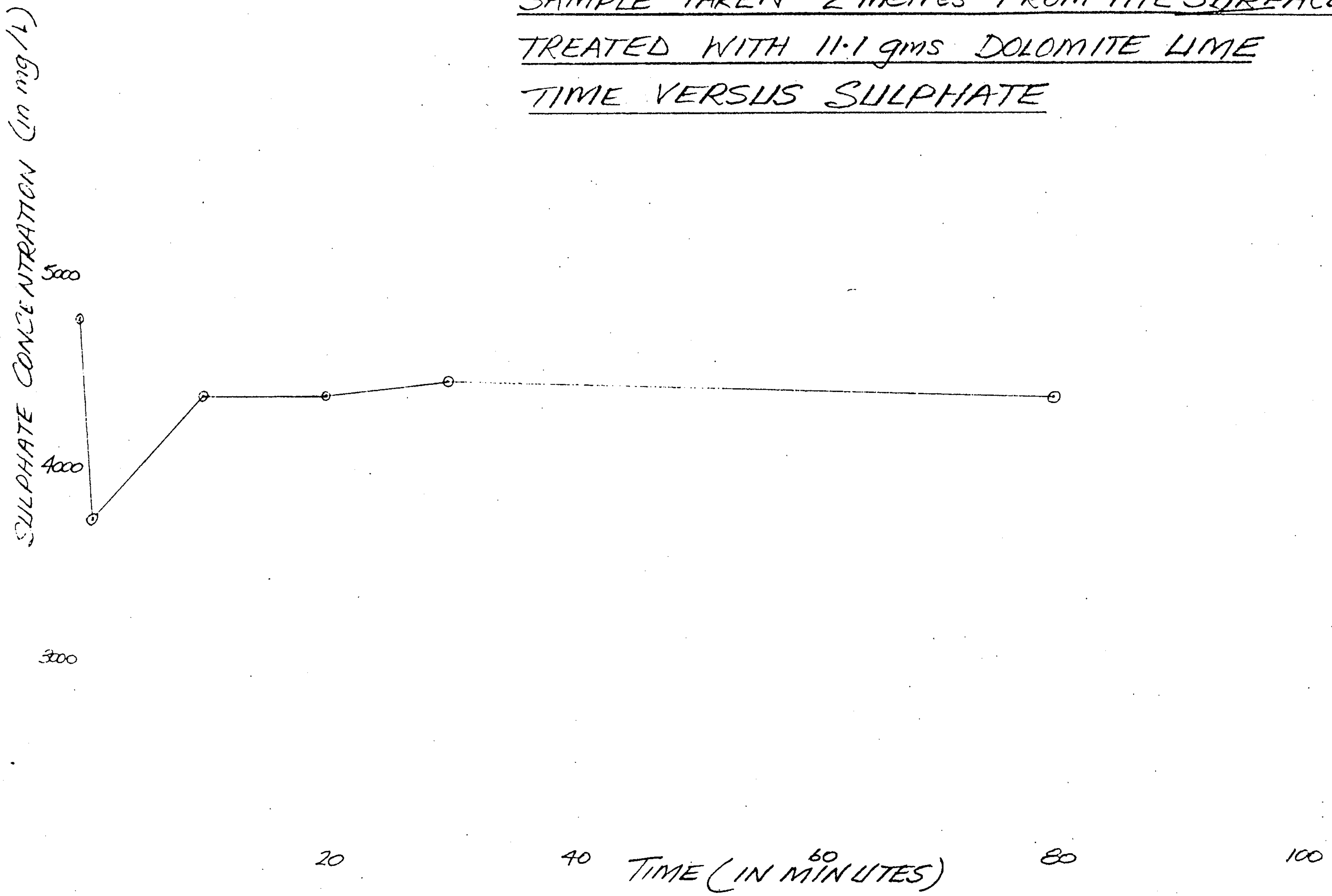


WHITES OPENCUT

SAMPLE TAKEN 2 metres FROM THE SURFACE

TREATED WITH 11·1 gms DOLOMITE LIME

TIME VERSUS SULPHATE

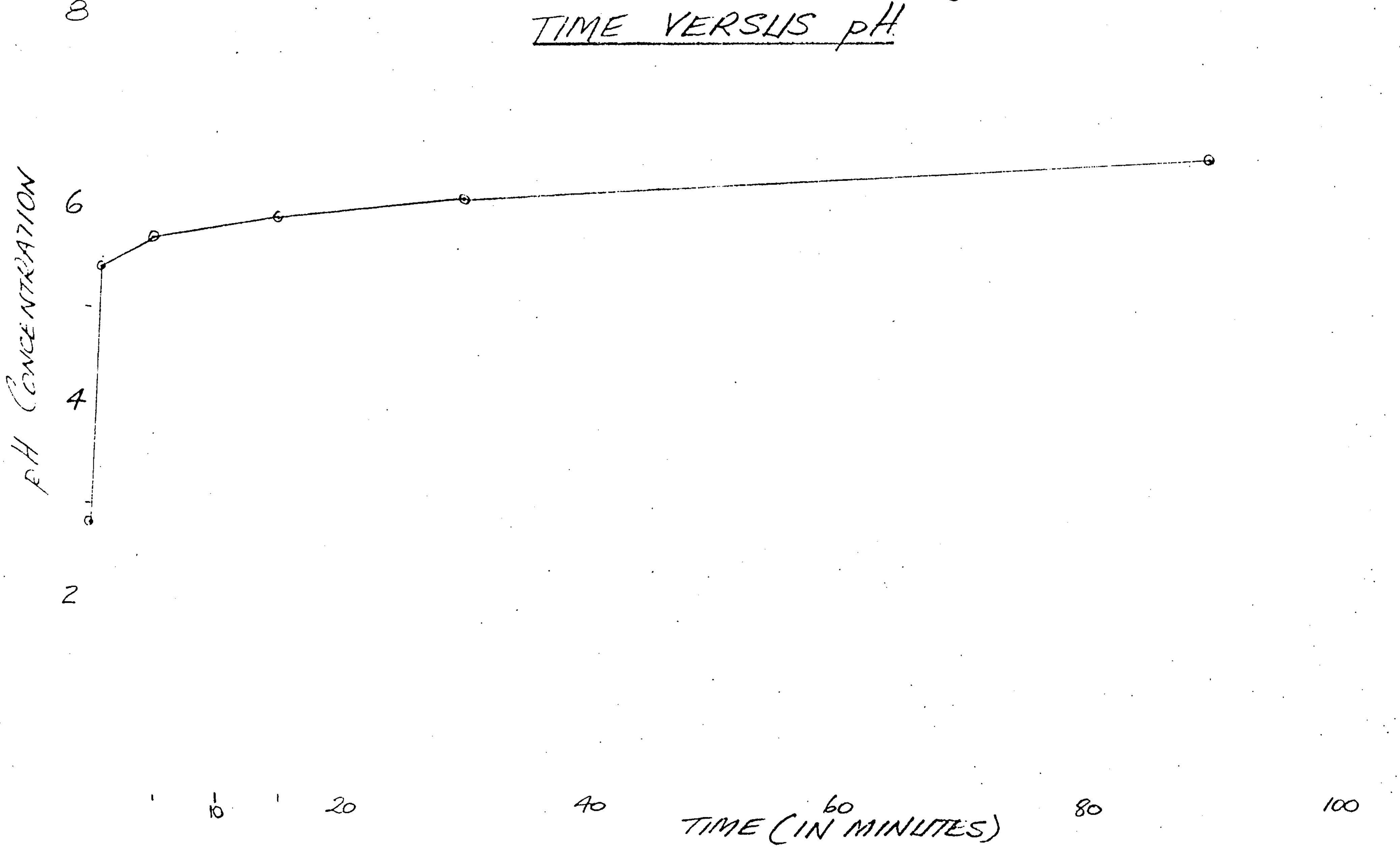


WHITES OPEN CUT

SAMPLE TAKEN 2 metres FROM SURFACE

TREATED WITH 4.44gms CALCIUM CARBONAT

TIME VERSUS pH

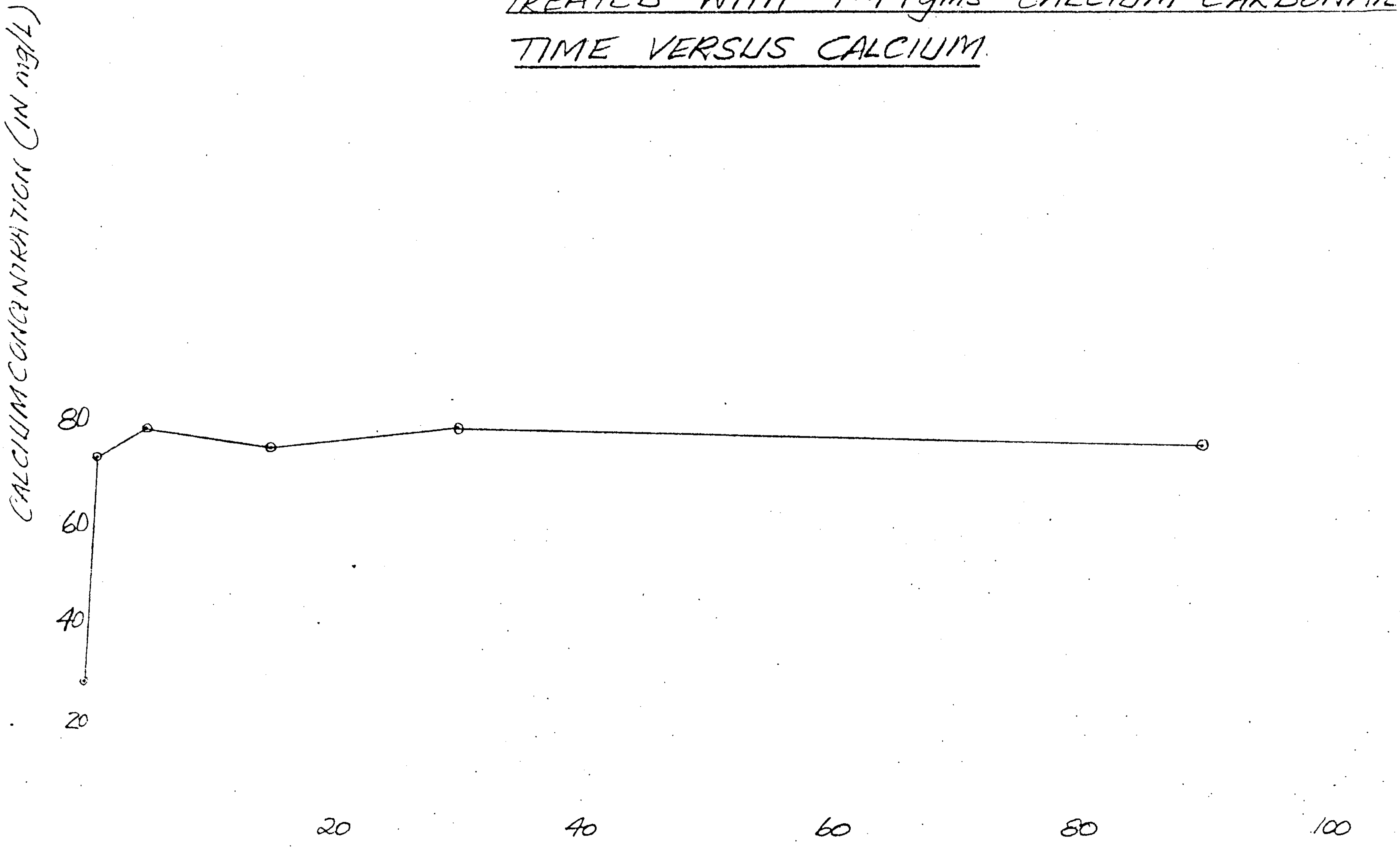


WHITES OPEN CUT

SAMPLE TAKEN 2 metres FROM THE SURFACE

TREATED WITH 4.44gms CALCIUM CARBONATE

TIME VERSUS CALCIUM

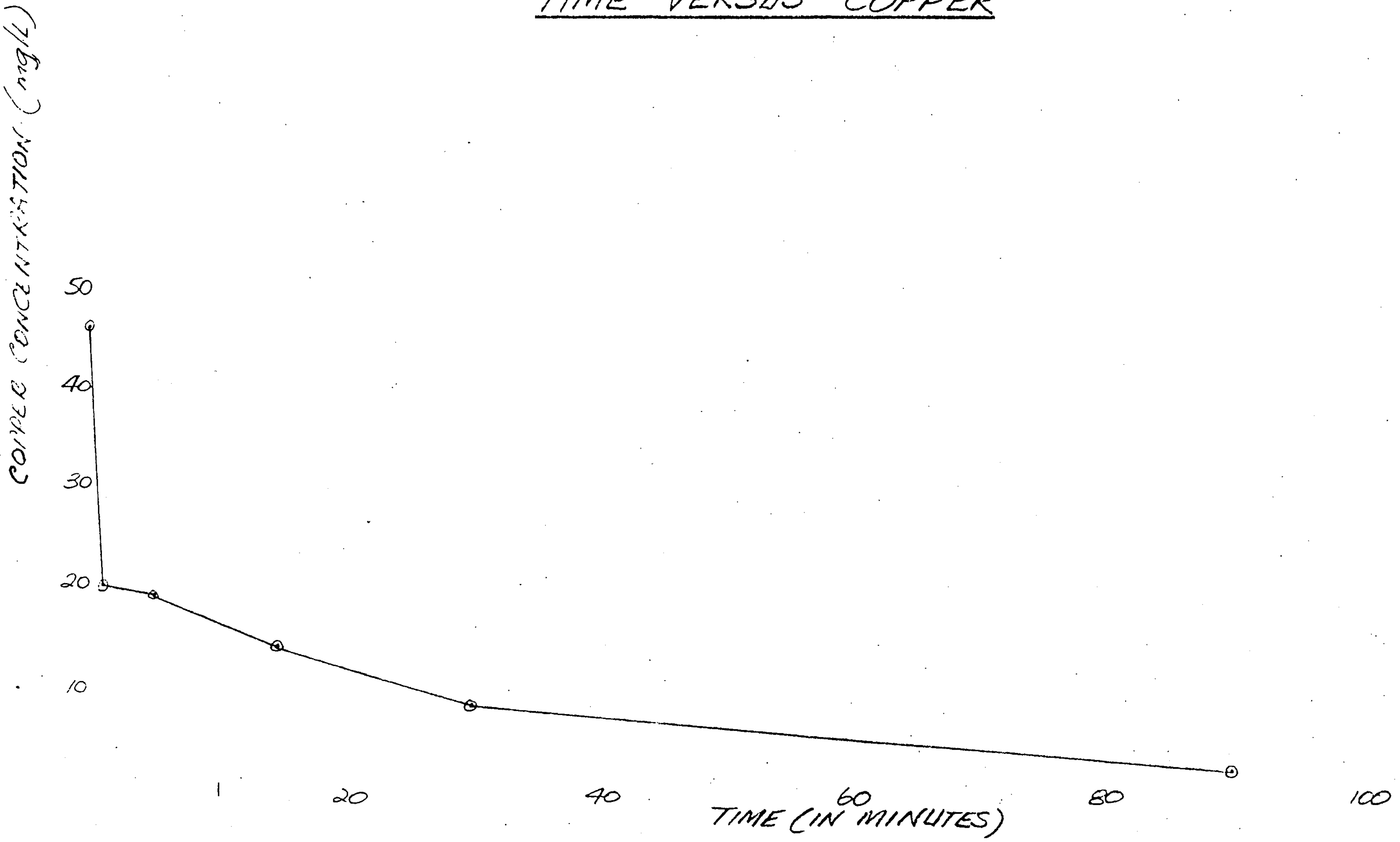


WHITES OPEN CUT

SAMPLE TAKEN 2metres FROM THE SURFACE

TREATED WITH 4.44gms CALCIUM CARBONATE

TIME VERSUS COPPER

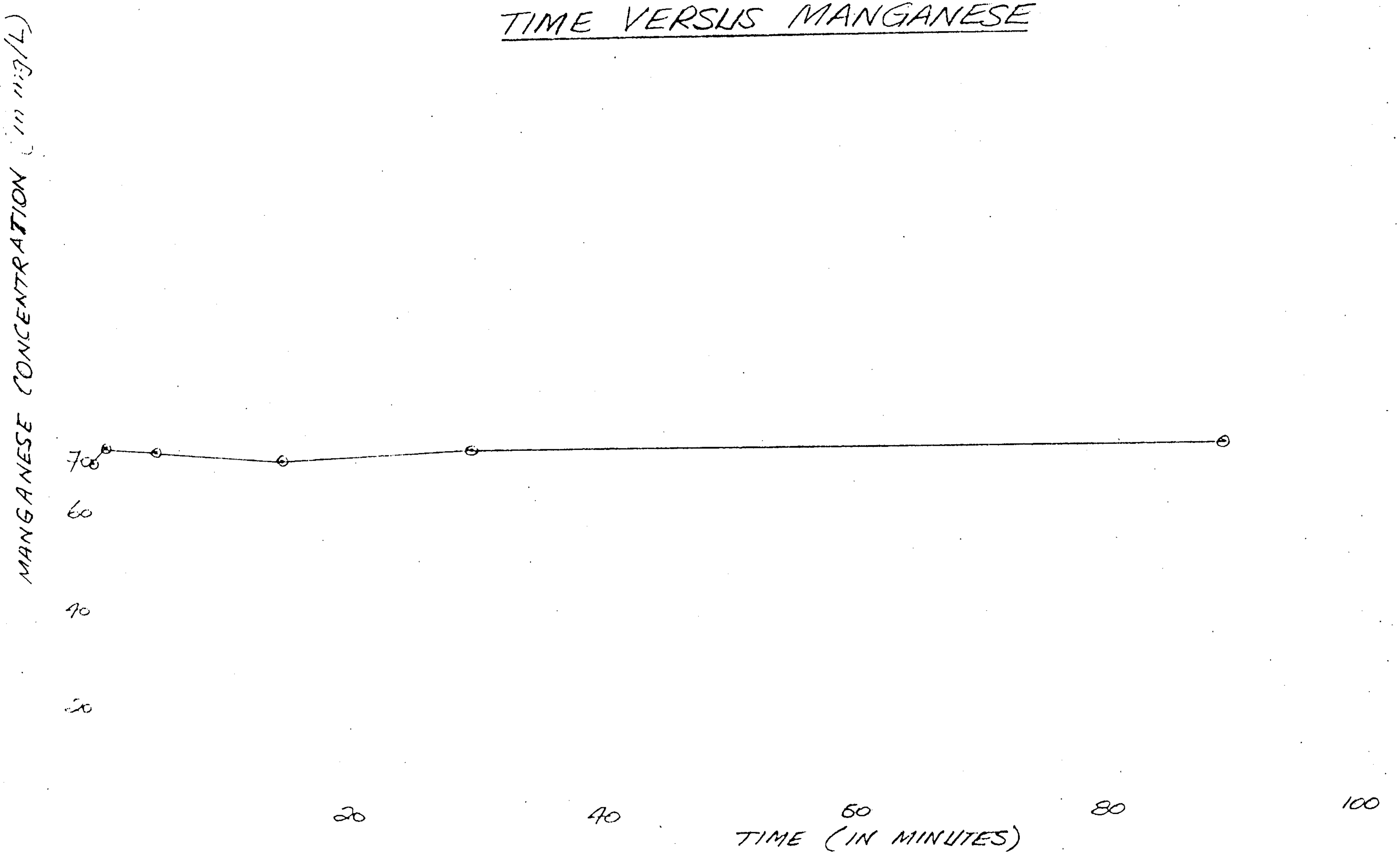


WHITES OPEN CUT

SAMPLE TAKEN 2 metres FROM THE SURFACE

TREATED WITH 4.44 gms CALCIUM CARBONATE

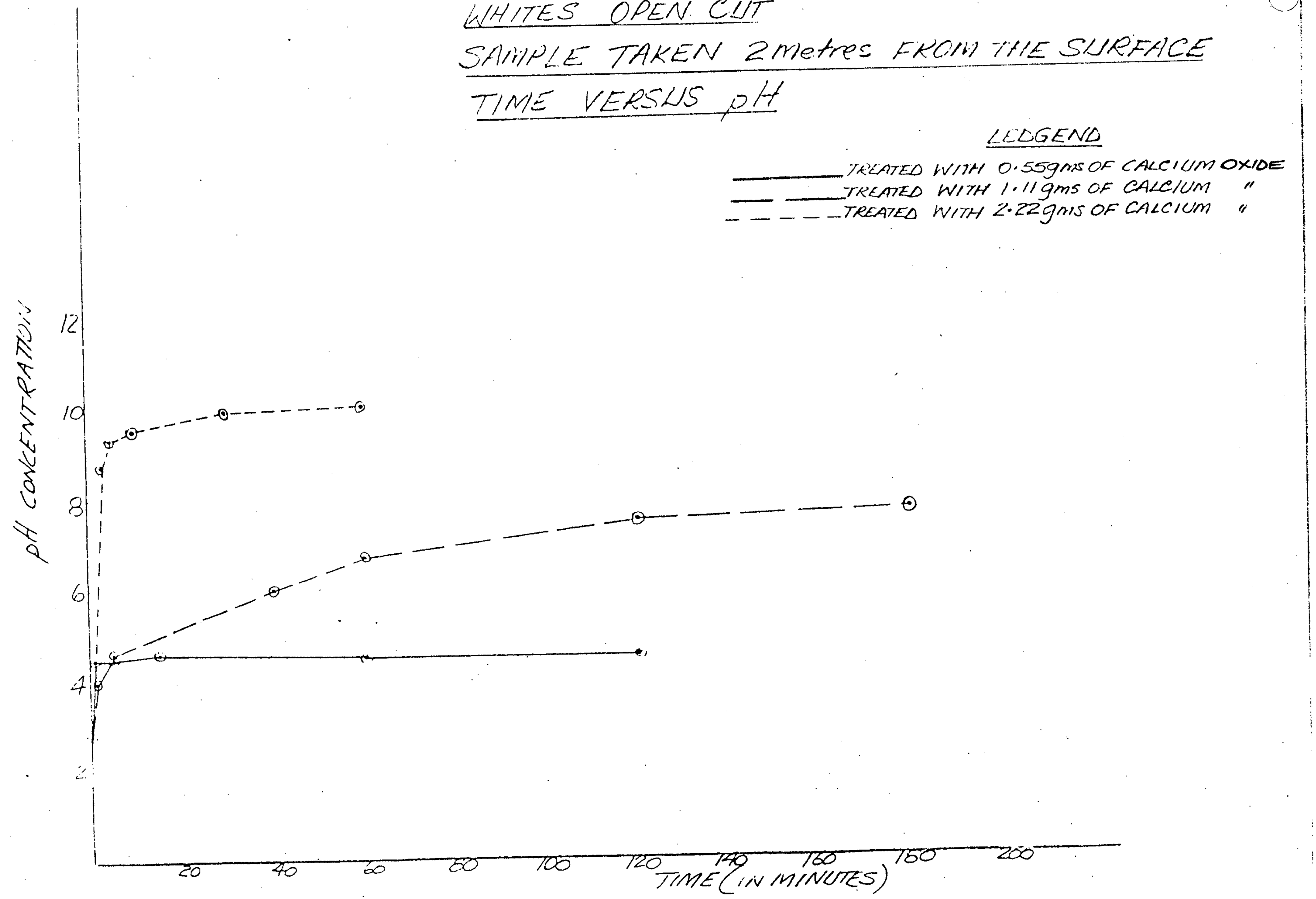
TIME VERSUS MANGANESE



WHITES OPEN CUT

SAMPLE TAKEN 2 Metres FROM THE SURFACE

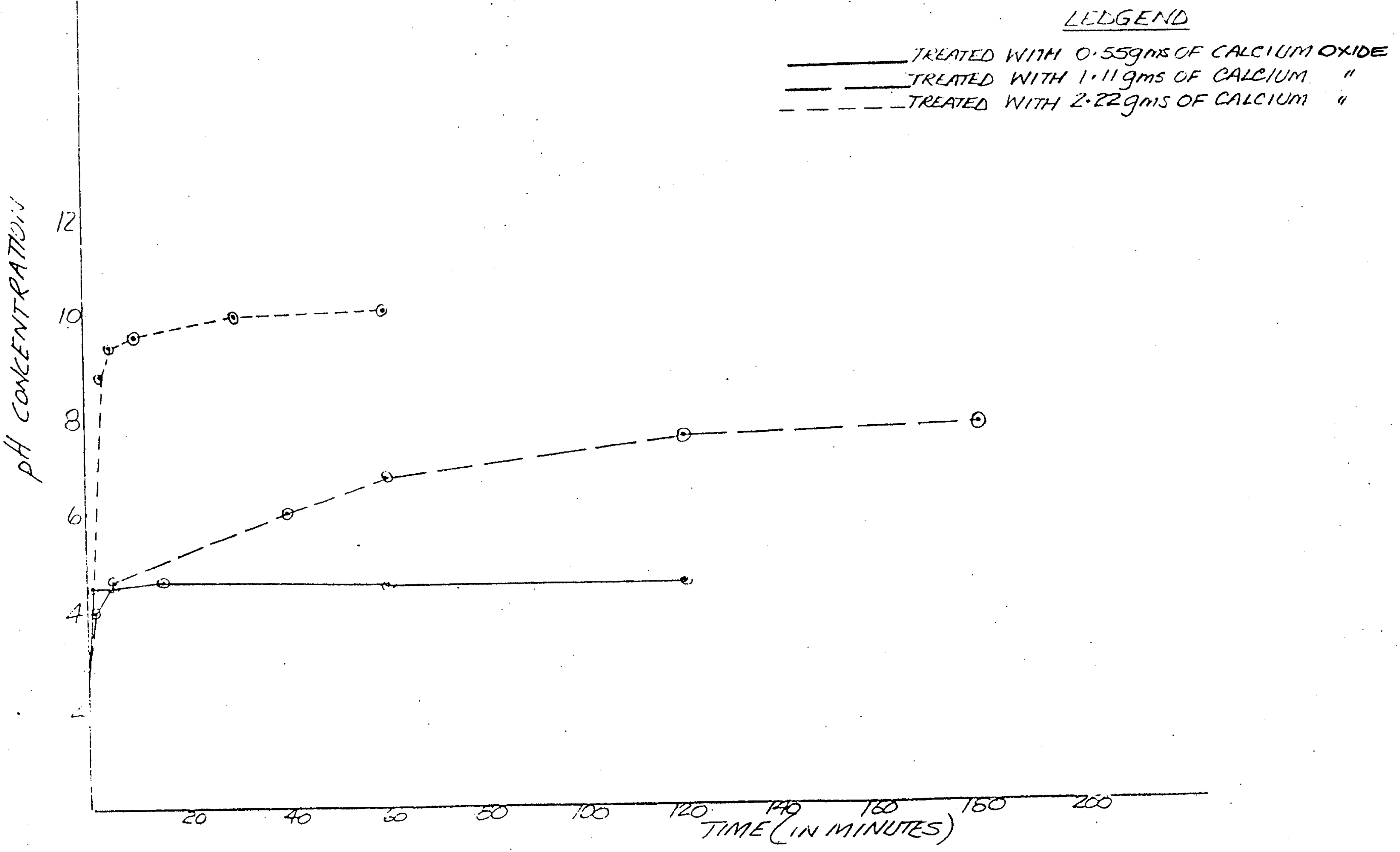
TIME VERSUS pH



WHITES OPEN CUT

SAMPLE TAKEN 2 Metres FROM THE SURFACE

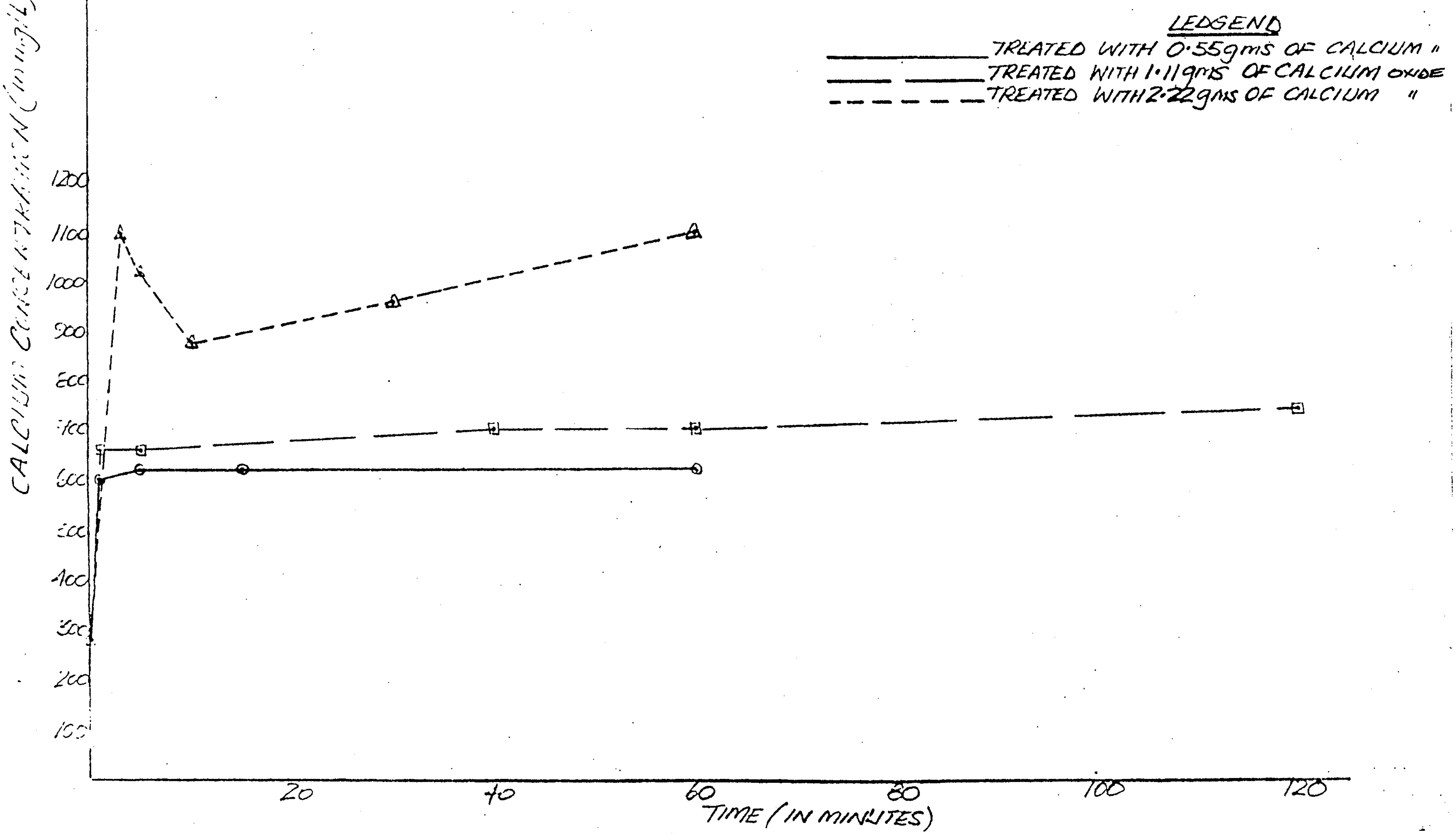
TIME VERSUS pH



WHITES OPEN CUT

SAMPLE TAKEN 2metres FROM THE SURFACE

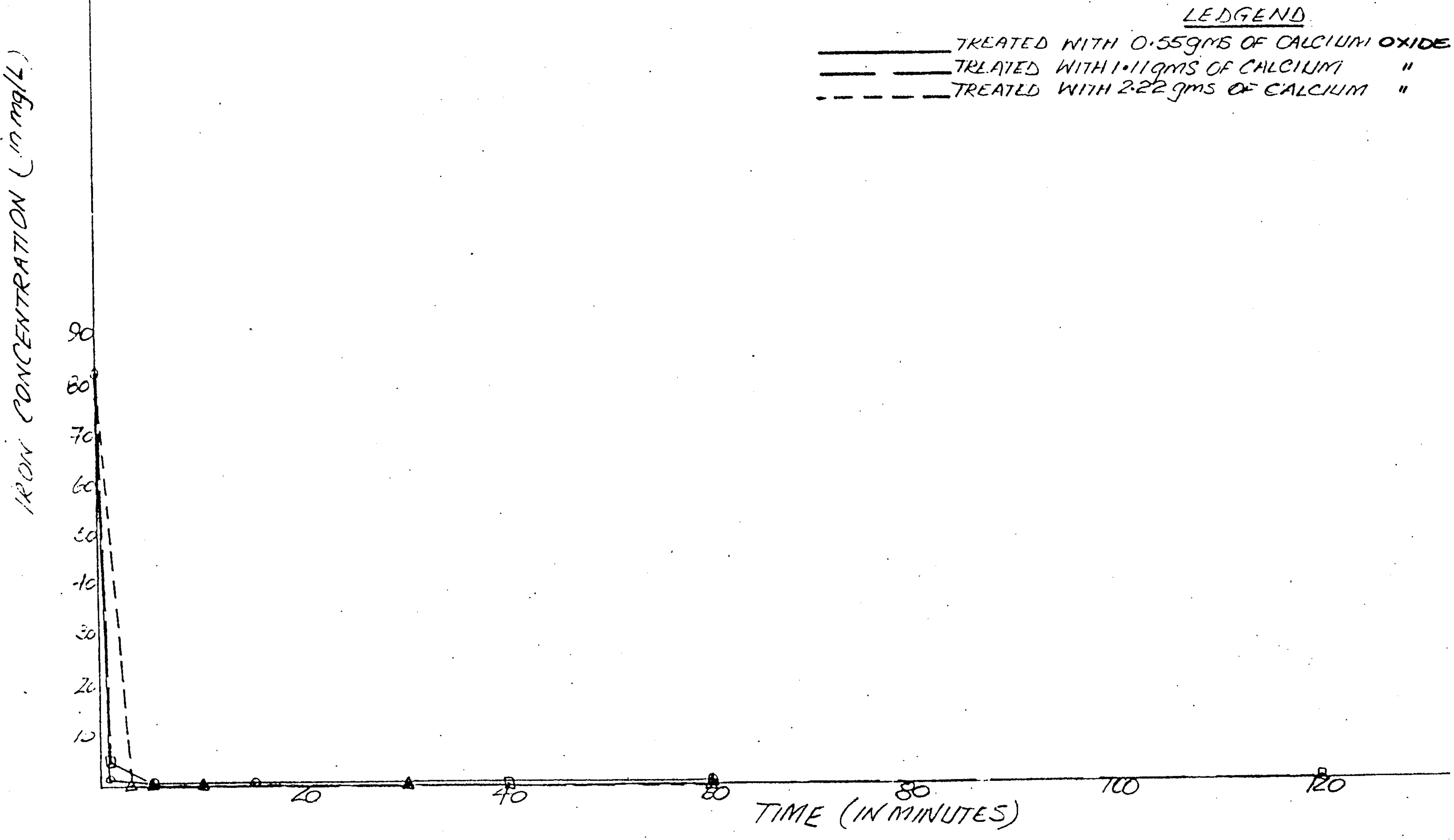
TIME VERSUS CALCIUM

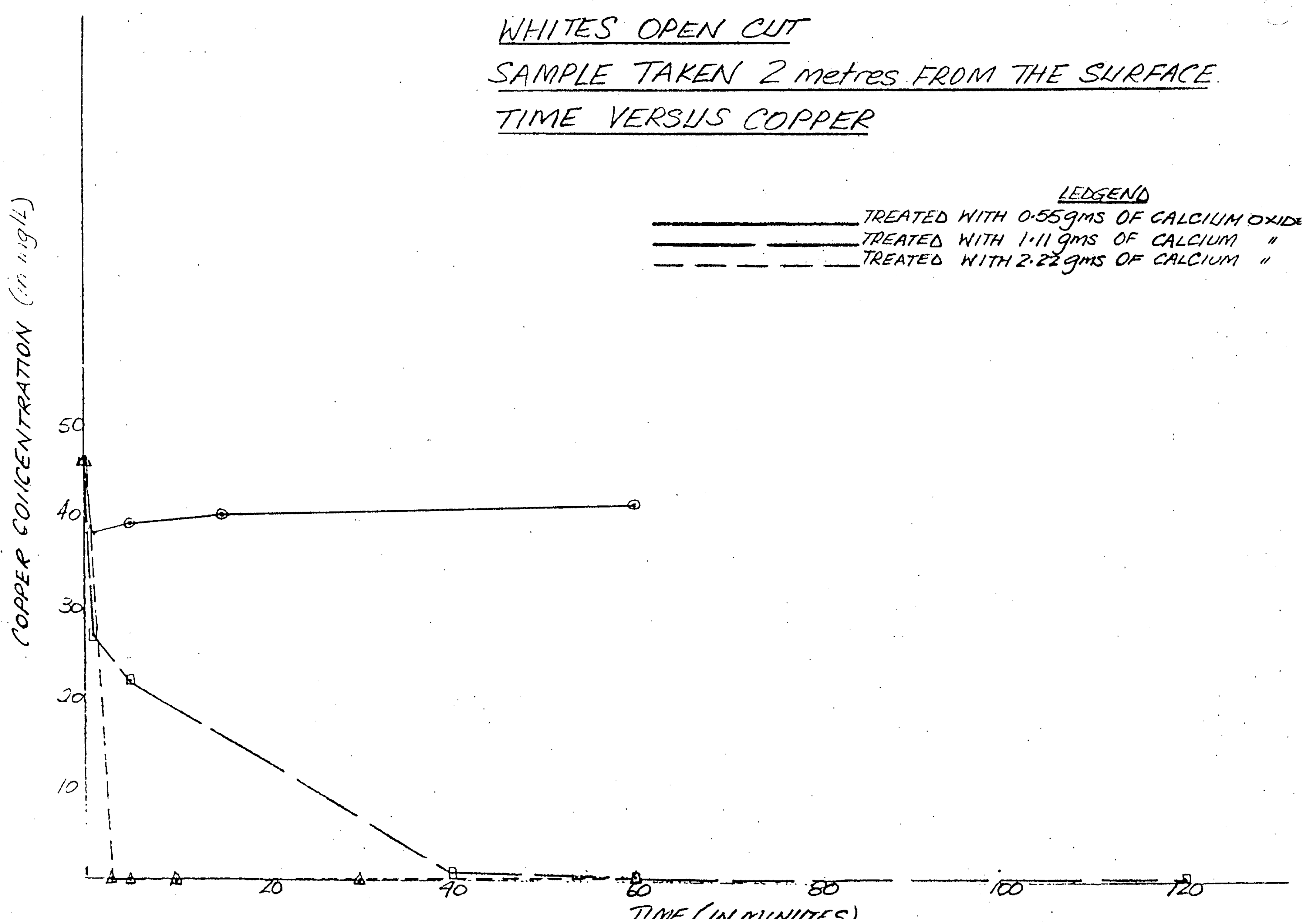


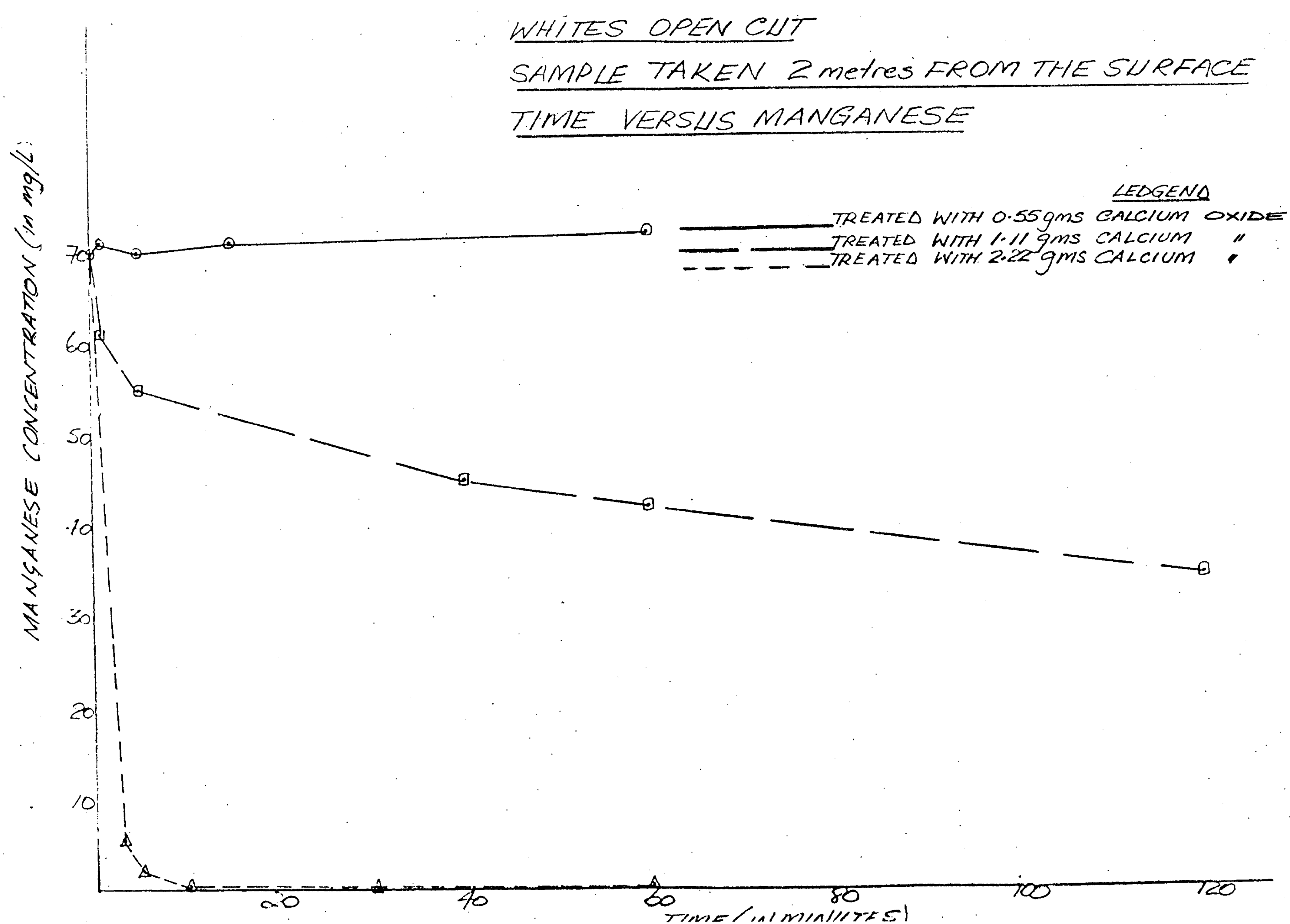
WHITES OPEN CUT

SAMPLE TAKEN 2metres FROM THE SURFACE

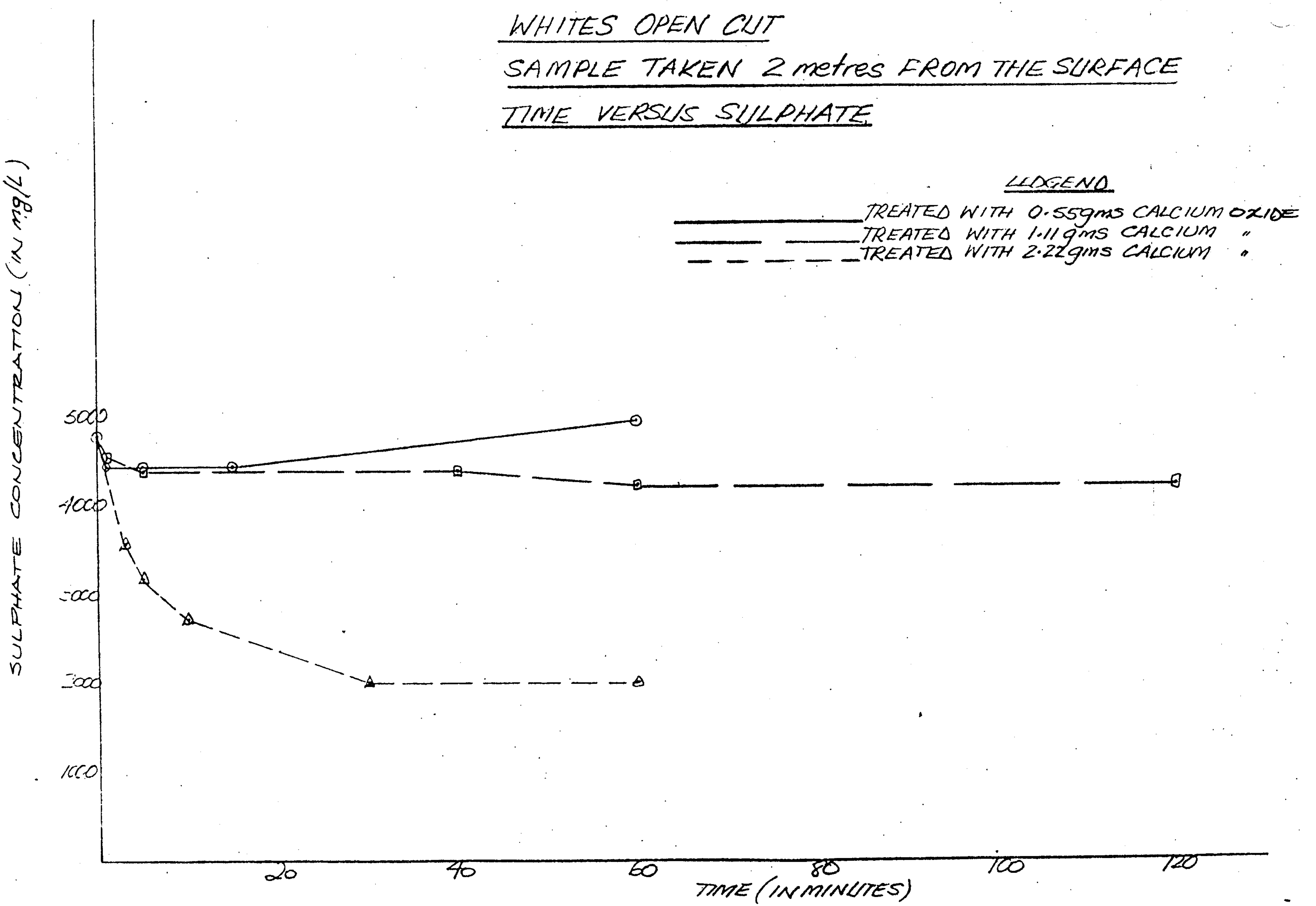
TIME VERSUS IRON




WHITES OPEN CUT
SAMPLE TAKEN 2 metres FROM THE SURFACE
TIME VERSUS COPPER
LEDGEND
TREATED WITH 0·55gms OF CALCIUM OXIDE
TREATED WITH 1·11 gms OF CALCIUM "
TREATED WITH 2·22gms OF CALCIUM "
COPPER CONCENTRATION (in mg/L)
50
40
30
20
10
20
40
60
80
100
120
TIME (IN MINUTES)



WHITES OPEN CUT
SAMPLE TAKEN 2 metres FROM THE SURFACE
TIME VERSUS MANGANESE
LEDGEND
TREATED WITH 0·55 gms CALCIUM OXIDE
TREATED WITH 1·11 gms CALCIUM "
TREATED WITH 2·22 gms CALCIUM "
MANGANESE CONCENTRATION (in mg/L)
70
60
50
40
30
20
10
20
40
60
80
100
120
TIME (MINUTES)

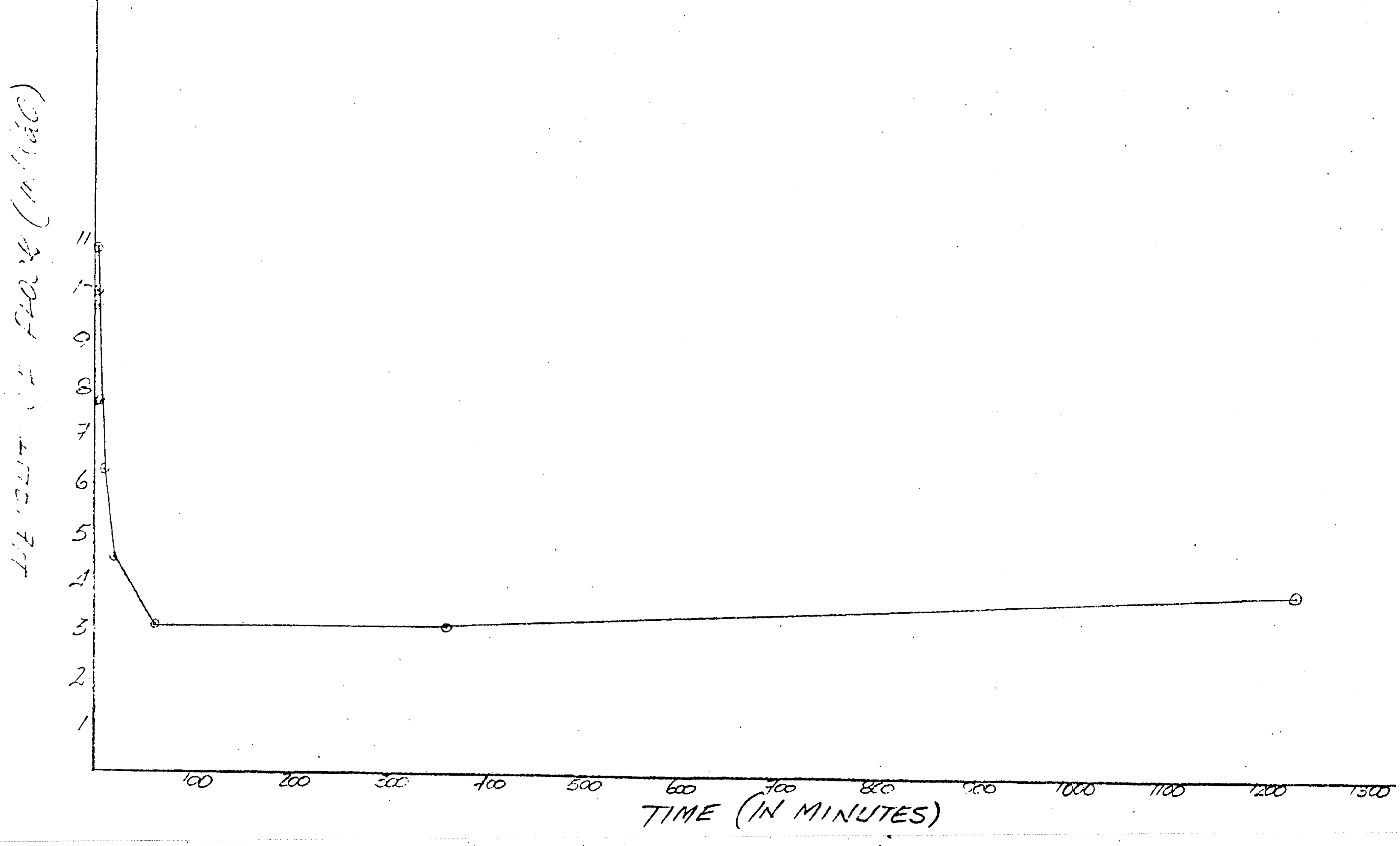


WHITES OPEN CUT
SAMPLE TAKEN 2 metres FROM THE SURFACE
TIME VERSUS SULPHATE
LEGEND
TREATED WITH 0.55gms CALCIUM OXIDE
TREATED WITH 1.11gms CALCIUM "
TREATED WITH 2.22gms CALCIUM "
SULPHATE CONCENTRATION (IN mg/L)
5000
4000
3000
2000
1000
20
40
60
80
100
120
TIME (IN MINUTES)

WHITES OPEN CUT - SAMPLE TAKEN 2metres FROM THE SURFACE

TREATED WITH 2·22gms/litre LIME (CaO)

TIME VERSUS DEPTH



ANALYSIS

CALCIUM CARBONATE

CaO	50.7%	Approx 90%	$CaCO_3$
SiO_2	1.5%		
MgO	1.9%		

GARDEN DOLOMITE

CaO	25.2%	MgO	16.5%
SiO_2	12.5%		

CALCIUM OXIDE

CaO	91.6%
MgO	3.3%
SiO_2	1.9%