ANGLO AMERICAN PACIFIC LIMITED

KALGOORLIE TAILINGS RETREATMENT PROJECT

PUBLIC ENVIRONMENTAL REPORT

JANUARY 1988

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

ANGLO AMERICAN PACIFIC LIMITED

KALGOORLIE TAILINGS RETREATMENT PROJECT

PUBLIC ENVIRONMENTAL REPORT

JANUARY 1988

Prepared by

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

KALGOORLIE TAILINGS RETREATMENT PROJECT

PUBLIC ENVIRONMENTAL REPORT

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Public Environmental Report (PER) for the proposed Kalgoorlie Tailings Retreatment Project has been prepared in accordance with Western Australian Government procedures. The report will be available for comment for eight weeks, beginning on 30 January 1988 and finishing on 26 March 1988.

The proponent is Anglo American Pacific Limited (AAP) who has held Licences to Treat Tailings (LTTs) in the Lakewood area, Boulder for many years. Test work and financial evaluation has revealed that it is economic to extract the residual gold. AAP now wishes to proceed with the project and is seeking government approval. The EPA requires that this PER be reviewed by the public before government approval can be granted.

Following receipt of comments, the EPA will discuss the issues raised with the proponent, and may ask for further information. The EPA will then prepare its Assessment Report with recommendations to Government, taking into account issues raised in the submissions.

WHY WRITE A SUBMISSION?

A submission is a way to provide information, express your opinion and put forward your suggested course of action, including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received will be acknowledged.

DEVELOPING A SUBMISSION

You may agree or disagree, or comment on, the general issues discussed in the PER or with specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the PER,

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable, and
- suggest recommendations, safeguards or alternatives.

POINTS TO KEEP IN MIND

By keeping the following points in mind, you will make it easier for your submission to be analyzed.

Attempt to list points so that the issues raised are clear. A summary of your submission is helpful. Refer each point to the appropriate section or chapter in the PER. If you discuss sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering.

Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Please indicate whether your submission can be quoted, in part or in full, by the EPA in its Assessment Report.

REMEMBER TO INCLUDE:

Your name, address, date.

The closing date for submission is 26 March 1988.

Submissions should be addressed to:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH WA 6000

Attention: Ms D Peggs

INDEX (CONT'D)

INDEX (CONT'D)

TABLES

APPENDICES

PLATES

INDEX (CONT'D)

PUBLIC ENVIRONMENTAL REPORT

KALGOORLIE TAILINGS RETREATMENT PROJECT

for

ANGLO AMERICAN PACIFIC LTD

SUMMARY

INTRODUCTION

Anglo American Pacific Ltd (AAP) proposes to develop a project (KALTAILS) which will reprocess old gold tailings dumps located on the fringe of the Golden Mile, to the south-east of Boulder townsite. At least 32.5 Mt of tailings on 15 Licences to Remove and Treat Tailings (LTTs) held by the proponent are to be reprocessed, although up to 57 Mt may ultimately be treated if additional dumps currently held by others are incorporated into the project.

Following submission of a detailed Notice of Intent for the project in September 1987, the Environmental Protection Authority (EPA) advised AAP that this Public Environmental Report (PER) should be prepared, and should be made available for public review.

The proposal involves the construction of a treatment plant and support facilities capable of reclaiming and retreating up to 12 000 t of tailings each day. The method of treatment is essentially a cyanide leach, followed by a combined carbon-in-leach/carbon-in-pulp (CIL/CIP) gold recovery circuit. The tailings will be reclaimed by high pressure water guns, and transported in slurry form to the treatment plant.

After treatment, the tailings will be deposited into a new tailings storage, at a new site, which will be designed, constructed and managed to facilitate long-term stability and rehabilitation of the completed storage.

The project is expected to employ a workforce of 67 people, conducting a seven-day, twenty-four hour operation, for a project life of up to 14 years.

SITE SELECTION

The project has essentially three separate components -

- Reclamation, Transfer and Services Area
- Borefield and Water Supply Area
- Treatment Plant and Tailings Disposal Area.

The Reclamation, Transfer and Services Area comprises the existing dumps themselves, and a limited area adjacent to the dumps necessary for the collection of the slurried tailings and transfer by pipeline to the plant. It includes a pipeline and services corridor between the reclamation area focal point and the treatment plant site.

The Borefield is located to the south-east of the project area, and is developed in a major aquifer which has been evaluated as the only viable source of water to meet the large water requirement of the project. The 21 production bores in the water supply borefield will be connected by a 28 km pipeline and powerline corridor, following the shortest practicable route to the plant site.

The only flexibility in site selection applies to the location of the Treatment Plant and Tailings Disposal Area.

Much of the land around the project site is already committed to a land use which would preclude it from consideration as a site for the new tailings storage. This includes the Kalgoorlie-Boulder townsites, Aboriginal Reserves, Railway Reserve and private residential land holdings outside the townsites. Included also is the major mining zone of the Golden Mile and its northern and southern extensions, incorporating the existing mining operations and the proposed Big Pit developments.

Various alternative sites within the areas not committed to an exclusive land use have been considered by AAP, taking into account technical, environmental and economic factors. Included in this evaluation were the options of disposal of the tailings into mined out open cuts, and incorporation of the tailings disposal into the area set aside by North Kalgurli Mines Ltd (NKML) as a Waste Zone for its Big Pit development proposal. Both of these options have been found to be unavailable.

Firstly, the Big Pit mining proposals and the need to maintain access from open cuts for possible future underground mining development precludes any extensive backfilling of old pits with either waste rock or tailings (Department of Mines, 1988). Secondly, NKML's Waste Zone, which is subject to height restrictions because of the proximity of Kalgoorlie Airport, is insufficiently large to accommodate the approximately 300 ha required by the KALTAILS project for tailings disposal.

Sites below the assumed flood level of 330 m AHD or within active drainage zones have been rejected because of the risk to long-term stability of the tailings storage from a major flood event.

The site preferred by the proponent for the treatment plant and new tailings storage lies approximately 3 km east of the focal point of the existing dumps, between Lakewood Townsite and the Trans Australian Railway line. The site is covered by a Mining Lease M 26/82, held by AAP. It is a timbered site and lies largely within the Lakeside Timber Reserve, a reserve set aside for sandalwood preservation.

Alternative sites to the north-east of the Trans Australian Railway, and south of Kalgoorlie-Boulder to the west of Celebration Road, would both be more attractive from environmental considerations, but have been rejected by the proponent on economic grounds, as seriously jeopardising the economic viability of the project.

The existing tailings dumps have long been a source of airborne dust problems in Kalgoorlie and Boulder. The proposed removal, treatment and disposal to a new site, further away from the urban areas, is seen as a major benefit to the community, and was a principal factor taken into account in the site selection process.

EXISTING ENVIRONMENT

The existing dumps are situated in an area which has undergone severe environmental impact, from mining, pastoral and urban fringe activities. The area is sparsely vegetated, and is completely devoid of large trees. There is also an extensive area of outwash of tailings material downslope as a result of erosion from the dumps.

The land slopes gently to the south towards the Hannan Lake saline depression.

Moving east towards the proposed plant/tailings disposal site, the services corridor crosses a broad drainage line before entering progressively more vegetated country, initially with sparse shrub cover and finally moderately timbered.

The proposed plant and tailings disposal site lies within the timbered zone, which has in the past been clear-felled, but is now subject only to sporadic firewood collection. Part of this woodland has been set aside as a timber reserve.

The water supply pipeline and borefield extends to the south-east of the proposed plant site across moderately to sparsely wooded terrain. The line passes initially through the timber reserve, then into pastoral leases.

The whole project area drains generally to the south, with a gentle gradient into the Hannan Lake depression. Apart from the broad drainage line just east of the existing dumps, drainage lines are poorly developed, and sheetflow or intermittent channel flow predominate in the runoff pattern.

The Trans Australian Railway lies to the north-east of the project development, and the presence of the railway embankments has, to some extent, modified the south and south-westerly drainage pattern, so that there is now more defined channelling in the drainages close to the railway line.

Geologically, the project lies within the Archean Yilgarn Block. The underlying basement rocks comprise a series of ultramafic belts (which are of major economic importance), intruded by granitic rocks. The basement rocks are deeply weathered, and with minimal cover apart from deep sections of valley-fill in old paleodrainages. The valley-fill alluvium includes some permeable sands which constitute an important aquifer. The groundwater within this aquifer system is hypersaline, with salinities up to more than 100 000 mg/L total dissolved solids (TDS). However, this groundwater is suitable for gold processing use, and is proposed as the source of water for the KALTAILS project.

The climate of the project area is semi-arid, with predominantly winter rainfall, but with occasional summer storms of high intensity. Surface runoff is sporadic, and of short duration.

There is no extensive use of the surface water resources in the region, other than for stock use from farm dams. There is also no potable quality groundwater in the region, and the only use of groundwater is for gold processing and other minor mining and industrial uses.

An existing borefield located 1.5 km south of the proposed plant site supplies process water to NKML's Fimiston plant. The water supply pipeline passes through the south-western corner of M 26/82. Several other projects obtain water supplies from similar borefield developments in the broader region.

The project area is not known to contain any endemic flora or fauna which are rare or endangered. The Lakeside Timber Reserve, however, represents the closest sandalwood reserve to Kalgoorlie.

There are no registered Aboriginal sites within the project area.

ENVIRONMENTAL IMPACT AND MANAGEMENT

The project will impact on the existing environment in areas of new construction, but will also remove a major source of dust from Kalgoorlie-Boulder.

AAP will appoint a project rehabilitation/environmental officer at commencement of the project to undertake the necessary air and water quality monitoring, design and implementation of progressive rehabilitation works, and the conduct of research in revegetation.

The main areas of potential impact of the project are as follows:

Water

There are no downstream users of surface water, and the only downstream use of groundwater is for gold processing. Consequently, the potential impact of tailings disposal on other water users is negligible.

The new tailings storage has been designed with an efficient underdrainage system to recover seepage and the storage will be managed to maximize water recovery. Hence, the potential for seepage losses will be low. The presence of an impervious substrate at shallow depth will facilitate control of seepage losses.

The initial embankment has been designed to enable complete retention of the theoretical peak maximum precipitation, and successive stages of raising the embankments will be timed to ensure the dam maintains this capacity at all times. Consequently, the risk of overtopping during extreme rainfall/flood events is negligible.

The process water supply for the project has been designed to allow for continued operation of all other existing and planned borefields in the region, without detrimental impact on either quality or available yield.

Due to the very low recharge rates, this water supply, as with the other groundwater developments in the region, is based on the resource being "mined" (ie pumped at a rate greater than the natural rate of replenishment).

Through the optimum use of saline water by the project, and maximizing water recovery from the tailings dam, the project's demand for potable water from the Goldfields and Agricultural Water Supply Scheme will be very small.

Flora and Fauna

There will be a loss of vegetated area from the site of the treatment plant and new tailings storage, and to a lesser extent from the pipeline/powerline route to the borefield and the slurry line/services corridor from the existing dumps to the plant. There will be a consequential loss of habitat for the fauna from the cleared areas.

The area of loss from the storage and plant site comprises 315 ha, which is small compared with the ecological units affected, and even with the size of Lakeside Reserve itself (3 787 ha).

Rehabilitation works will improve the prospects for ultimate natural revegetation of the area occupied by the existing dumps. The borefield pipeline corridor will also be conditioned to assist natural revegetation. Revegetation trials will be conducted on the final slopes of the new tailings storage, with a view to restoring the storage to a stable and ecologically acceptable condition.

Dust

Dust generation during the project will be minimal, due to the use of hydraulic mining which will preclude the need for trucks, apart from minor cleanup operations. Local dust generation may occur for short periods during the initial construction phase and during subsequent raising of the tailings storage embankments.

The project will remove one of the major causes of the current dust problems at Kalgoorlie-Boulder.

The new tailings storage will be progressively rehabilitated to minimize the potential for future dust generation after project closure. Likewise, the area currently occupied by the dumps will be progressively rehabilitated, leading to eventual revegetation or stable cover to minimize ongoing dust generation.

Transportation

Over the life of the project, traffic movements will be limited to short periods of activity during initial construction and the subsequent rehabilitation activities.

Noise

Noise impact from the use of hydraulic monitors will be minimal due to the low overall noise generation compared with conventional mining methods, and the remote operation of the monitors.

Overall noise impact of the project will be minimal.

Social

The project will contribute to an improved quality of life in Kalgoorlie-Boulder through removal of one of the major causes of dust generation.

The project will offer employment opportunities to 67 people, which will have a direct and flow-on benefit to the local community and the State.

Rehabilitation

Salvageable timber will be recovered during clearing operations.

Topsoil will be removed from the tailings storage site and stockpiled for subsequent replacement on the final embankments to encourage revegetation.

Revegetation trials will be conducted during the course of the project, and attempts will be made to progressively revegetate the final slopes of the tailings storage after cover with waste rock and landscaping to produce stable, aesthetic landforms. At completion, the top surface of the tailings storage will be ripped, covered with a stable blanket, and windrowed to facilitate eventual natural revegetation in time.

The existing tailings dam areas will likewise be ripped, covered with a stable blanket, and after a period to permit leaching of residual salts, subjected to revegetation trials.

CONCLUSION

The Kalgoorlie Tailings Retreatment Project is an important gold recovery project, with economic benefit to AAP, and a flow-on benefit to the Kalgoorlie-Boulder community and the State. It represents an opportunity to remove one of the major sources of dust pollution in the area, and to relocate the tailings further from the urban areas, and in an engineered structure designed for long-term stable containment of the tailings into the future. This will contribute significantly to an improvement in the quality of life for the Kalgoorlie-Boulder community.

MAJOR ENVIRONMENTAL COMMITMENTS

1. General

- Appoint a rehabilitation/environmental officer responsible for all monitoring programmes, revegetation trials and liaison with CALM.

2. Mined Tailings Dumps

- Restore about 300 ha, staged to follow monitor station moves.

- Restoration Programme (to be carried out only with the permission of all underlying tenement holders):

(1) Characterize soil, cross-rip and cover with 35 - 40 mm nickel slag, or equivalent.
(2) Leave to leach for at least two years.
(3) Construct wind rows of planting medium and conduct revegetation trials.
(4) In the event that revegetation is unsuccessful, cover with waste rock or equivalent, as dust and erosion protection.

3. New Tailings Storage

- Salvage timber and stockpile topsoil.

- Construct an underdrainage system to return seepage to the plant.

- Maintain freeboard at all times to contain a Probable Maximum Precipitation of 860 mm, plus wave action.

- Progressively flatten the outer embankments and cover with at least 1 m of waste rock or equivalent to create a final slope of 1:4, or flatter. Cover with a layer of topsoil and mulch, and conduct revegetation trials.

- Maintain a maximum slope length of 30 m by constructing 5 m berms on the outer slope.

- In the event that revegetation on the outer embankments is unsuccessful, armour with further waste rock or equivalent, as erosion protection.

- Rehabilitate the top surface upon decommissioning by cross-ripping and covering with nickel slag or equivalent to minimize dust and enhance leaching. The surface will then be either revegetated or armoured, depending on the results of revegetation trials.

- Monitor the tailings storage throughout the project life, and commission independent and qualified consultants to review the following data recorded by the proponent to reassess the operational procedures:

(1) Pressure heads in embankments and foundation.
(2) Settlement of embankments.
(3) Return water quantity and quality.
(4) Strength of tailings in embankments.
(5) Survey of embankment and beach levels.
(6) Dust levels, including one year of baseline measurement.
(7) Groundwater levels and quality in bores downstream of storage, including one year of baseline measurement.
(8) Bird activity.

4. Water Supply

- Maximize return water from tailings storage.
- Bury water supply pipelines.
- Minimize clearing of pipeline track by following existing easements and cleared lines as far as possible.
- Divert pipeline around large trees, wherever possible.
- Replace and rake soil to promote natural regrowth following pipeline installation.
- Construct sumps to contain water discharged during drilling and testing, and at scour valves.
- Design abstraction rates to minimize the effect on adjacent groundwater users.
- Monitor and assess the performance of the aquifer throughout the project life.

5. Social

- Provide employment for about 67 persons.
- Provide additional housing.

6. Project Closure

- The rehabilitation programme will be completed and the project sites will be cleared of debris when the project closes.

ABBREVIATIONS

AAP	Anglo American Pacific Limited
AGC	Australian Groundwater Consultants Pty Limited
AHD	Australian Height Datum
^0C	Degrees Celsius
CALM	Department of Conservation and Land Management, Western Australia
CIP/CIL	Carbon-in-pulp/carbon-in-leach process
CN^-	Cyanide ion
CSIRO	Commonwealth Scientific and Industrial Research Organization
DCE	Department of Conservation and Environment
db	Decibels
EPA	Environmental Protection Authority
ERGO	East Rand Gold and Uranium Co Ltd, an AAP associated mine in South Africa
Fe^{2+}	Iron ion
FRP	Fibreglass Reinforced Plastic
G	General Purpose Lease
GDAC	Goldfields Dust Abatement Committee
GSWA	Geological Survey of Western Australia
g/t	Grammes per tonne
ha	Hectares
HCN	Hydrogen cyanide gas
HDPE	High Density Polyethylene (pipe material)
KALTAILS	Kalgoorlie Tailings Retreatment Project
kg	Kilogramme
kL	Kilolitre
kL/d	Kilolitres per day
km	Kilometre
KMA	Kalgoorlie Mining Associates
km/hr	Kilometres per hour
kV	Kilovolts
L	Miscellaneous Licence
LTT	Licence to Remove and Treat Tailings
m, m^3	metre, cubic metres
M	Mining Lease
mg/L	Milligrammes per litre
mg/mL	Milligrammes per millilitre
$M.m^3$	Million cubic metres
mm/hr	Millimetres per hour
m^3/s	Cubic metres per second
MPa	Megapascals (measure of pressure)
Mt	Million tonnes, million tonnes per annum
MW	Megawatts
NaCN	Sodium Cyanide
NKML	North Kalgurli Mines Limited
NOI	Notice of Intent
oz	Ounce
P	Prospecting Licence
PER	Public Environmental Report
SECWA	State Energy Commission of Western Australia
t	Tonne
TDS	Total Dissolved Solids
t/ha	Tonnes per hectare
tpd	Tonnes per day
μm	10^{-6} metres
WAIT	Western Australian Institute of Technology (now Curtin University)
WAWA	Water Authority of Western Australia
Zn^{2+}	Zinc ion

1. INTRODUCTION

1.1 Objective

The Kalgoorlie Tailings Retreatment (KALTAILS) Project involves the reprocessing of gold tailings, situated mainly on the south-eastern fringe of the Golden Mile, south-east of the Boulder townsite (Plate 1). There are 32.5 Mt of tailings currently available, and possibly up to 57 Mt will be finally retreated.

The Anglo American Group has a total of fifteen (15) Licences to Remove and Treat Tailings, thirteen (13) of which are held by the wholly owned subsidiary, Mulga Mines Pty Ltd, and are located south-east of Boulder as indicated above. The two (2) remaining licences are held by another subsidiary, Australian Anglo American Searches Pty Ltd, and are located close to the northern boundary of the Kalgoorlie Township. The feasibility of treating the two northern dumps will be evaluated during the life of the project. The LTT licences are renewed annually and applications have been made to renew all these licences.

Kalgoorlie Mining Associates (KMA) has general purpose leases on most of the other tailings dumps in the Lakewood area and the Anglo American Group is currently negotiating with KMA to retreat their two major areas of tailings.

The current proposal requires the construction of a retreatment plant and support facilities capable of reclaiming and retreating up to 12 000 t of tailings each day. The method of treatment is essentially a cyanide leach followed by a combined CIL/CIP (carbon-in-leach/carbon-in-pulp) gold recovery circuit. The proposed reclamation procedure will involve the use of several high pressure water guns to avoid the generation of dust and to keep operating costs at an acceptable level.

At the indicated treatment rate of 12 000 tpd, and assuming tailings reserves of 57 Mt, the project is expected to have a life span of approximately fourteen (14) years from the completion of commissioning.

The proposal calls for the construction of a relatively simple process plant employing a direct labour force of approximately sixty seven (67) people conducting a seven (7) day, twenty four (24) hour operation. The company anticipates recovery of an estimated 16 500 kg, or just over 530 000 oz, of fine gold, with a comparable amount of silver, from the operations.

1.2 Location

As indicated in 1.1, the proposed project is situated south-east of Kalgoorlie-Boulder (Figure 1 and Plate 2). A detailed map of the existing tailings areas, and the available plant site and tailings disposal area, is presented as Figure 2 (see also Plate 3).

The Tenement Maps are presented as overlays to Plates 2 and 3, and indicate the relationship between the Kaltails tenements and underlying and nearby tenements held by others.

The project essentially has three separate sections -

- Borefield and Water Supply Line
- Plant and Tailings Disposal Area
- Reclamation Transfer and Services Area.

1.3 Ownership

Thirteen (13) of the licences are held by Mulga Mines Pty Ltd, a wholly owned subsidiary of Anglo American Pacific Ltd (AAP) and two (2) licences by Australian Anglo American Searches Pty Ltd (AAAS), also wholly owned by AAP Ltd.

TABLE 1

LICENCES TO TREAT TAILINGS (LTTs)

Dump No	Licence No	Owner
1	LTT 26/163 (2899H)	Mulga Mines Pty Ltd
3	LTT 26/148 (2781H)	Mulga Mines Pty Ltd
4	LTT 26/164 (2900H)	Mulga Mines Pty Ltd
5	LTT 26/223 (3669H)	Mulga Mines Pty Ltd
7	LTT 26/149 (2782H)	Mulga Mines Pty Ltd
8	LTT 26/139 (2726H)	Mulga Mines Pty Ltd
9	LTT 26/140 (2727H)	Mulga Mines Pty Ltd
	LTT 26/147 (2780H)	Mulga Mines Pty Ltd
	LTT 26/146 (2779H)	Mulga Mines Pty Ltd
10	LTT 26/183 (3180H)	Mulga Mines Pty Ltd
14	LTT 26/151 (2784H)	Mulga Mines Pty Ltd
16	LTT 26/224 (3671H)	Mulga Mines Pty Ltd
	LTT 26/161 (2897H)	Mulga Mines Pty Ltd
	LTT 26/141 (2728H)	Australian Anglo American Searches Pty Ltd
	LTT 26/136 (2723H)	Australian Anglo American Searches Pty Ltd

By agreement, the previous owners, Messrs Pinner and Dalla-costa, have royalty rights in respect of all the licences.

The licences to treat tailings (LTTs) are licences granted under the old Mining Act, 1904, which confer on the holder the right to remove and treat tailings, but confer no rights in respect of the underlying ground. The licences do not permit the disposal of the tailings back onto the same ground after retreatment.

Mining Lease M26/82, held by Mulga Mines Pty Ltd, covering an area of 465 ha, resulted from the amalgamation of four (4) mineral claims and has been set aside for the establishment of a new tailings disposal site.

It is proposed to apply for a Miscellaneous Licence covering the water supply borefield area and the pipeline, powerline and access road easements in connection with the water supply system. Application will also be lodged for a Miscellaneous Licence covering the routes of slurry pipelines, powerlines and access roads in connection with the tailings reclamation and transfer to the plant. Appropriate negotiations will be conducted with the holders of underlying tenements affected by these licences, as well as with the pastoral lease holders and other owners/occupiers of affected lands, as required by the Mining Act and Regulations.

1.4 History

Most of the tailings located in the area have been derived from gold-bearing ore mined from the Golden Mile. There is a small amount of nickel tailings resulting from the treatment of nickel ores. Some of the dumps have been retreated in the past.

- LTT 26/163 - Originally from Boulder-Perserverence and partly retreated by the Golden Horseshoe Operation
- LTT 26/146 - Parts of this dump have been retreated three times
- LTT 26/151 - Residues from the Chaffers Retreatment Plant.

The retreatment of LTT 26/163 was attempted twice but eventually abandoned as uneconomic. In the case of LTT 26/358, the original Golden Horseshoe Mine tailings dump was a high, pyramid-shaped dump located approximately 1 km north-west from the present dump. The dump was treated a second time in the 1930's and 1940's in the Golden Horseshoe Retreatment Plant and then a third time in the same plant in the 1950's. The intermediate dump after the second retreatment was located approximately 500 m north-west from the existing dump. It is evident from aerial photographs that LTT 26/163 tailings were at least partly reclaimed using hydraulic (water gun) monitoring methods. More recent treatment occurred in 1983/4 when Kalamunda Commodities retreated 14 367 t from LTT 26/141 with a reported achieved gold recovery of only 0.19 g/t.

Subsequently, in 1984, the Grants Patch/Goult Pro Joint Venture treated 134 043 t, as permitted under the terms of the original vendor (Pinner/Dalla-costa) agreement. Reported gold recovery from this treatment was 0.62 g/t. As with the 1983 programme of Kalamunda Commodities, the tailings were reclaimed by the conventional earthmoving method.

Residential nuisance dust in and around Kalgoorlie and Boulder has been derived from three major sources:

- denudation of surfaces by pastoral and urban clearing activities
- the outer surfaces of tailings and waste rock dumps
- mining activities, including traffic, on the fringe of the residential zones.

The first reported recognition of a dust problem appeared in 1898 in the "Kalgoorlie Miner" newspaper which referred to dust generation resulting from tree clearing around the Kalgoorlie township.

The problem continued unabated until 1947 when a scheme to fence and revegetate some denuded areas was proposed by a Regeneration Committee comprising local authorities from Boulder and Kalgoorlie, and representatives of the Chamber of Mines and Government agencies. The scheme was abandoned after failing to reach a consensus regarding cost sharing.

Interest in dust abatement efforts fluctuated markedly thereafter and generally followed extended drought periods when dust levels became noticeably worse. "Green belts", or areas where tree cutting was prohibited, were established around the towns but were not strictly upheld or enforced on private land. No significant regeneration took place and the generally accepted 12 mile (radius) green belt was only partially successful in preventing the cutting of green timber. Public concern peaked after the severe dust storm of 6 October 1972. The problem was officially recognized and the Goldfields Dust Abatement Committee (GDAC) was established (Richmond et al, 1973).

Since the establishment of the GDAC, considerable research and some regeneration programmes have taken place (Nunn, 1981 and GDAC, 1984). Greening of the residential areas and fringes has resulted in a degree of dust suppression and considerable aesthetic improvements. However, one major source of the problem, the tailings dumps to the south-east of Boulder, persists due to difficulties in successfully revegetating or covering the dumps, the cost of works and uncertainties regarding future mining of the dumps. In its progress report for 1973-1981 (Nunn, 1981), the GDAC also considered the aesthetic and historical value of the dumps in their options for dust abatement methods.

1.5 Infrastructure

The attached Location Map (Figure 1) outlines the recommended locations of all facilities and service routes. Primary service corridors will be all weather access roads with adjacent pipelines and either permanent or temporary powerlines.

1.5.1 Roads

The principal access road is the existing sealed road (single lane) generally referred to as the Lakewood-Mt Monger Road. From the south-western corner of G 26/17, held by Great Boulder Mines Ltd, a new road will be constructed directly to the proposed central process plant/tailings area approximately 2.5 km to the east. The south-western corner of G 26/17 is generally referred to as the services "focal point". All services to or from the monitor stations will radiate from this point. Varying standards of construction for the access roads will be necessary depending on the expected life of each monitor station. LTT 26/149 will be reached from the new road to the plant/tailings area (Figure 2 and Plate 3).

1.5.2 Powerlines

The main feeder line will be drawn from the SECWA transmission lines adjacent to the Kambalda Road at a point near the southern extremity of the existing tailings deposits then east and north-east to the services focal point. This 33 kV line will then follow the main access road to the central plant. Subject to the final feasibility study, a branch from this feeder will be directed to each monitor station as required. A major feeder line will be taken from the central plant complex to the borefield.

1.5.3 Water Supply

The water supply for KALTAILS will be drawn from a borefield to be constructed south-east from the plant site/tailings disposal area. This borefield will draw water from an alluvial aquifer developed within a buried paleochannel of Tertiary age. The water will be hypersaline, with an expected salinity in the range 90 000 - 120 000 mg/L total dissolved solids (TDS) and pH in the range 3.5 - 8.

The borefield collector pipeline will extend to a distance of approximately 28 km south-east from the plant, with up to 21 production bores spaced at about 1.3 km intervals along the pipeline route.

The pipeline will be constructed of HDPE, or alternative corrosion-resistant materials, and will be buried for security and environmental reasons. Where possible, the pipeline route will follow existing cleared accessways (the North Kalgurli pipeline/powerline easement, the Mt Monger Road, and an old woodline).

The borefield water pipeline will terminate at a lined 40 000 kL pond adjacent to the central plant. For reclamation of tailings, water will be pumped from this pond along a pipeline beside the main access road to the focal point and then to the operating monitor station, into a 500 kL surge tank.

The production bores will be constructed of fibreglass reinforced plastic (FRP) casing and in-line stainless steel screens, and will be equipped with bore pumps of corrosion-resistant construction. Observation bores will be constructed at intervals through the borefield area for monitoring purposes.

It is proposed to obtain the small domestic quality water requirements from the Kalgoorlie town water supply.

A portion of rainfall runoff entering the site will be intercepted and transferred to an off-stream storage dam adjacent to the tailings storage to provide fresh water for establishment of rehabilitation vegetation on the embankments.

2. EXISTING ENVIRONMENT

2.1 Regional Setting

The KALTAILS project will be located in an area within the Shire of Boulder which has experienced extensive disturbance in the past from gold mining activities. A major feature of the area is the group of large tailings dumps in the Lakewood area, which have both contributed to the visual unattractiveness of the area and been a major source of dust to the Kalgoorlie and Boulder town areas.

Beyond these tailings dumps to the east is a broad area, including the old Lakewood townsite, which is sparsely vegetated and is totally devoid of large trees as a result of timber harvesting and outwash from the adjacent mining areas to the west and north-west.

Further east, the country becomes progressively more heavily wooded and part of the area has been set aside as a timber reserve. Beyond the timber reserve to the east, the land, which is partly wooded, is held under pastoral lease.

Throughout the project area, the land slopes gently to the south or south-west, draining generally towards the saline depression occupied by Hannan Lake. Approaching the lake, the area becomes progressively less wooded, and eventually becomes saline flats, with occasional dune development.

The Trans Australian Railway crosses in a south-easterly direction to the north of the project area. Drainage lines are generally poorly developed, and the railway constitutes a major barrier to extensive sheetflow runoff, channelling the runoff to culverts located at each recognizable stream channel. The presence of the railway is likely to have had some impact on the downstream drainage patterns, tending to concentrate sheetflow into discrete channels.

The location of the various components of the project in relation to present land use are shown on Figures 1 and 2, and the overlays to Plates 2 and 3.

2.2 Geology

The project area lies within the Archean Yilgarn Block. The basement rocks of the Yilgarn system in the project area comprise a series of north/north-west trending ultramafic belts, which include an association of ultramafic to mafic intrusives and extrusives, acid volcanics, clastic and chemical sediments, which have been subsequently metamorphosed and intruded, deformed and enveloped by granites and gneisses (Williams, 1970). The ultramafic sequence has been extensively explored in recent years, and is highly prospective for gold exploration. A number of active gold mines operate close to the project site.

The basement rocks of the Yilgarn system have undergone very little structural deformation since the Archean time, and there is a break in geological deposition between the Archean and early Tertiary. Following peneplanation of the Archean shield, subsequent erosion created a network of deeply incised valleys during the early Tertiary time. With the onset of arid conditions, these major drainages have become infilled with sediments, comprising clays, sands and gravels, to depths of more than 100 m.

Frequently, a clean sand/gravel deposit is developed in the basal section of the paleochannels. A major trunk paleochannel and its tributaries occur just south of the project site.

Away from the trunk drainage lines, the Archean basement is overlain by a thin veneer of Tertiary to Recent alluvial and colluvial sediments, together with a deeply weathered profile extending up to more than 30 m. Rock exposures in the immediate project area are virtually non-existent.

Condemnation drilling has been undertaken over the area proposed for tailings disposal. The results of this work have indicated that there is no significant gold mineralization at shallow levels (Australian Groundwater Consultants Pty Limited, 1987b).

2.3 Geomorphology

The existing tailings dumps at Lakewood are located on the eastern flank of a low, northerly trending hill belt on which the main Kalgoorlie mining activity is located. The site is underlain by a deeply weathered profile, which is superficially overlain by a thin veneer of alluvial sands, gravelly sands and clays. Drainage of the site and the natural topography have been extensively modified by the presence of the dumps and by other mining activities.

Further east, the proposed plant site/tailings disposal area is situated on an alluvial-colluvial slope, and is underlain at quite shallow depth by deeply weathered basement rock. The topography is relatively flat, with a gentle, south-westerly slope of the order of 1 in 150. The site drains to the south-west towards Hannan Lake, via sheetflow and by a series of indistinct, shallow channels which cross the site.

The tailings disposal area is a relatively inactive landform, although localized shallow cutting and filling is periodically taking place in the surface drainage channels.

2.4 Hydrology

2.4.1 Surface Runoff

The site proposed for the plant and tailings disposal is crossed by a braided drainage system, which drains a catchment of approximately 10 km^2 upstream from the site. This catchment area lies almost completely upstream (north-east) from the Trans Australian Railway line, which is located about 200 m from the north-eastern corner of Lease M 26/82.

The presence of the railway embankment has influenced the downstream drainage patterns by concentrating sheetflow runoff into discrete channels. The channels, which are quite prominent close to the railway line, become more diffuse and dispersed to the south-west, and are not clearly recognizable at the southern boundary of the site.

Some runoff from the catchment is intercepted by pastoral stock dams (Noonan Dams) upstream from the railway. The dams will have a positive effect in reducing peak flow rates from the catchment onto the tailings disposal site.

Peak discharge rates from this catchment for selected return periods have been determined by the Main Roads Department Rational Method (Flavell, 1984) using peak rainfall intensities and empirical runoff coefficients. Using Flavell's formula for the Wheatbelt region of Western Australia, the critical duration for this catchment was calculated to be 1.8 hours. Rainfall intensities for a duration of 1.8 hours have been calculated using data for Kalgoorlie from Australian Rainfall and Runoff (IE Aust, 1977).

The estimated peak discharges into the tailings disposal area are:

TABLE 2

ESTIMATED PEAK DISCHARGES

Return Period (years)	Runoff Coefficient	Rainfall Intensity (mm/hr)	Discharge (m^3/s)
2	0.18	10.3	5
5	0.30	14.2	11
10	0.60	16.1	26
20	0.95	19.4	49

These discharges are shown plotted as a flood frequency curve on Figure 3.

The retarding influences of both the railway embankment and Noonan Dams within the catchment, upstream from the proposed tailings storage site, have not been evaluated, however they would have the effect of reducing the intensity of or attenuating the theoretical peak discharge rates derived above.

Local infiltration of runoff will generate some subsurface flow within the surficial sandy material which underlies the site to a depth of 1 - 2 m. Deeper percolation through the underlying clayey sediments will be minimal.

Runoff, at present, flows to the Hannan Lake depression, and will continue to do so when diverted around the tailings storage and plant area.

There are no stock dams downstream of the plant/tailings storage site, and no beneficial usage of surface water. The Hannan Lake environment is too saline to be considered as a usable water resource.

The Water Authority of Western Australia has no reliable quantitative flood data for the Kalgoorlie area. Local Kalgoorlie residents remember that Lakewood township remained just above the flood level of Hannan Lake in the summer of 1947/1948. The rainfall records for Kalgoorlie show that the highest monthly rainfall recorded in 42 years was 300 mm in February 1948. This is considerably higher than the second and third highest months which recorded 186 mm each in January 1967 and June 1967. Since Lakewood is above the 326 m contour and below the 330 m contour, it appears that the 330 m flood level will have a very low risk of exceedence over the life of the project.

2.4.2 Groundwater

Aquifers comprising the groundwater system in the vicinity of the project site include -

- Cainozoic alluvial sands/gravels/clays
- Tertiary paleochannel sands
- weathered Archean basement (granites, metasediments, ultramafics)
- fractured basement rocks.

A substantial depth of alluvium occurs in the deepest sections of the paleodrainages in the region. The basal section of this paleodrainage infill usually comprises a clean, permeable sand deposit, which constitutes the major aquifer in the region.

Considerable investigation drilling and testwork for water supply development has been carried out in the general project area in recent years (AGC 1985a, 1985b, 1987c). Several projects derive their water supplies from groundwater to supplement the supplies obtained from the Mundaring pipeline scheme water supply. The major aquifer developed for large scale abstraction is the Tertiary paleochannel system, which is proposed as the source of groundwater for KALTAILS. Other, smaller supplies are drawn from aquifers in the shallow Quaternary alluvium, principally in lateritic gravel bed horizons, and also to some extent from the weathered and fractured basement profile. Water supplies from the latter sources are generally restricted to limited storages of groundwater, and therefore constitute much less reliable sources of water than the principal aquifer system, the paleochannel aquifer.

The regional groundwater flow pattern is summarized on Figure 4. The groundwater flow generally follows the same broad drainage patterns as the surface water flow. However, there are instances where the groundwater flow crosses over present surface water divides, indicating that there has been some shift in drainage catchment boundaries between the Tertiary and the present time.

Groundwater recharge occurs primarily by infiltration of rainfall and locally collected runoff, principally around the margins of the catchments where basement outcrops predominate. Locally collected runoff infiltrates through streambed channels and over areas of exposed fractured basement rock traversed by the streams, and thence flows subsurface down-gradient towards the major trunk valley centres, before joining the down-valley groundwater flow to the east. The ultimate discharge point for groundwater in the region is the Eucla Basin, some 200 km to the east of Kalgoorlie, however there are believed to be a number of local terminal points in the flow system associated with the chain of saline lakes which occupy the valley centres throughout the region. Accordingly, the net rate of down-valley flow of groundwater is extremely small.

While recharge clearly does occur, as evidenced by an increasing salinity gradient from catchment margins to the central valley areas and thence downstream to the east, the mechanisms and frequency of recharge events are poorly understood. Certainly recharge rates are low. Consequently, the exploitation of groundwater resources in this area is based on recovery of water from storage, rather than from interception of recharge.

The recoverable groundwater resources contained within the paleochannel aquifer can be approximately calculated as 2 - 3 $M.m^3$ of water per km length of paleochannel. In addition to the water stored within the sand aquifer itself, additional contributions of water from adjoining and overlying less permeable sediments will help to extend the available resources.

All groundwater in the immediate project area is of saline to hypersaline quality. In the paleochannel aquifer, salinities range from approximately 60 000 mg/L near the headwaters of the drainage and minor tributaries (AGC, 1985a), to between 130 000 and 200 000 mg/L in the downstream areas and areas proximal to terminal saline lakes. Within the basement (weathered and fractured profiles) and also in the Quaternary alluvium, variable salinities occur, in the range 40 000 to more than 100 000 mg/L.

While most of the groundwater is marginally acidic, with pH in the range 5-7, it is not uncommon to find sections of the aquifer system which contain water with a pH as low as 2-3.

2.5 Climatology

The project area is located in a semi-arid region of inland Australia, where the average annual rainfall is 257 mm/yr (median 231 mm/yr). The recorded range for Kalgoorlie is from 125 mm (lowest) to 488 mm (highest) in 1969 and 1963, respectively.

There is more rainfall in the winter months than the summer months, however summer storms regularly occur and often result in high intensity, short duration rainfall events. These storms account for a significant proportion of the yearly rainfall as illustrated by the average monthly rainfall figures shown in Table 3, which are based on the Bureau of Meteorology data for Kalgoorlie from 1939 to 1986.

Although a significant proportion of rainfall occurs in summer, the climate is much drier because of the high temperatures and the resulting high evaporation rates. The monthly temperature, rainfall and evaporation totals for each month are presented on Figure 5. These figures show that the peak evaporation in summer is more than four times the minimum winter evaporation and the mean maximum temperature in summer months is in excess of 30^0C. Potential evaporation exceeds average precipitation for all months of the year.

TABLE 3

RAINFALL DATA FOR KALGOORLIE

Month	Average Total Rainfall (mm)
January	21
February	29
March	20
April	20
May	27
June	31
July	27
August	20
September	15
October	16
November	18
December	13
ANNUAL AVERAGE	257

The combination of wind with high temperature produces the highest evaporation rates, and it is the cause of the highest airborne dust levels. The wind roses presented in Figures 6 to 9 show the wind regime throughout the year and the diurnal trends. In the summer, the winds are more often from the east and south-east, typically at speeds of 11 - 20 km/hr, and are steady throughout the day. In the winter months, the mornings are often calm and the wind increases throughout the day. Winter winds are predominantly from the west to north-west. In spring, the wind patterns are in transition from winter to summer patterns and the direction often shifts from east and south-east in the morning to north and north-west in the afternoon. The most frequent wind speed range throughout all seasons is 11 to 20 km/hr, however high speed winds in excess of 30 km/hr are more common in winter and spring than in the summer.

2.6 Air Quality and Dust in the Goldfields

Since the late 1800's, dust has been a feature of life in Kalgoorlie and Boulder. In the early part of this century, prior to the development of large tailings dumps, noticeable increased levels of dust resulted from the denudation of surfaces surrounding the towns, mostly as a result of timber clearing and grazing.

Dust levels are highest in the summer months, when evaporation is highest and dry winds from the south and south-east are predominant. A comparison of average summer and winter dust levels from twelve dust gauges located in and around the Kalgoorlie-Boulder townships is presented in Figure 10.

The results are expressed in units of Total Dirtiness. This is an optical unit of measurement, whereby the amount of dust is computed from the amount of obscuration it causes to the intensity of a light path of known calibration. By way of comparison, Total Dirtiness levels (annual average) for Kalgoorlie and the Perth urban area are presented in Table 4.

TABLE 4

AVERAGE TOTAL DIRTINESS LEVELS FOR URBAN PERTH AND KALGOORLIE[1]

Perth		Kalgoorlie	
Residential	0 - 3	South Kalgoorlie School	10 - 15
Commercial	3 - 5	Elizabeth Street	5 - 10
Industrial	5 - 10	Great Boulder Mine	10 - 15

[1]From Nunn, 1981.

The locations of the dust gauges measured on Figure 10 are shown in Table 5. Review of these data show that South Kalgoorlie, Eastern Goldfields and East Kalgoorlie Schools, Elizabeth Street and the Great Boulder Mine record dust levels which would normally result in dust nuisance complaints in the Perth metropolitan area (Nunn, 1981).

TABLE 5

LOCATIONS OF DUST GAUGES

(Ref Figure 10)

Gauge No	Location
1	Great Boulder Mine
2	South Kalgoorlie School
3	East Kalgoorlie School
4	Eastern Goldfields High School
5	Boulder Central School
6	South Boulder School
7	Boulder Caravan Park
8	West Kalgoorlie Freight Yards
9	Kalgoorlie School
10	North Kalgoorlie School
11	Killarney Street, Lamington
12	Elizabeth Street, Kalgoorlie

Richmond et al (1973) identified the tailings dumps south-east of Kalgoorlie and Boulder as the major source of dust pollution in the district.

Attempts to reduce this major source of dust by stabilizing the dumps have met with various problems, such as -

- the high salinity of the dump material
- the steep side slopes of the dumps
- exposure to winds, which impeded the establishment of vegetation on the dumps and embankments

- the low, long-term moisture holding capacity of the dump material, especially during the summer months
- the unavailability and/or cost of fresh water for irrigation programmes
- the high cost of complete rock blanket armouring programmes
- uncertainty regarding the future mining of the dumps.

Consequently, despite the considerable research efforts of various departments and committees, the problem remains and dust levels on the eastern side of Boulder/Kalgoorlie are considered to be unacceptable in comparison to levels in urban Perth (Richmond et al, 1973).

KALTAILS will contribute significantly to alleviation of the dust problem by removal of about four-fifths of the existing tailings dumps to the south-east of Boulder and relocation to a site more than 5 km away from the town areas.

2.7 Flora and Fauna

2.7.1 General

A limited field examination of the project area was carried out in early June 1987 (McArthur and Associates, 1987). The principal aim was to delineate the main ecological structural units, map the area, sample the flora, fauna and soil systems and evaluate the comparative validity of the existing related, documented information.

The area was broadly mapped from aerial photographs, ground checked, and sites located to represent the principal formations and associations. Colour photographs (prints) were taken at representative sites through the study area.

The study area includes geomorphological, floral and faunal associations which are widely represented in the Kalgoorlie region. Relevant literature and a limited field survey have revealed no significant ecological condition in the area, although the development proposal lies partly within the Lakeside Reserve, a Department of Conservation and Land Management Reserve for the protection of sandalwood.

The area is characterized by low drainage divides with shallow drainage channels. The vegetation is dominated by Eucalyptus woodland with complex understorey variations influenced by the drainage pattern. The southern portion is saline flats surrounding Hannan Lake.

The area between the existing tailings dumps and the proposed plant/tailings disposal site is either simple broad drainage flats, often saline, or severely degraded erosion zones of the dumps.

Previous knowledge of the region is limited largely to broadscale soil and vegetation mapping, respectively by Northcote, et al (1968) and Beard (1978). Additional biological information of the region has been compiled as a result of the Biological Surveys Committee objectives in 1977, resulting in several systematic surveys and the progressive Biological Survey of the Eastern Goldfields. The survey of the Kurnalpi-Kalgoorlie area, which includes the study area, has yet to be published. These studies have formed the basis of comparative site, habitat and ecological associations over the study area. A limited amount of information, mostly dating from the 1930's, was available from regional files of the Department of Conservation and Land Management. In all cases, virtually no detail specific to the study area was available.

The study area is categorized into five surface drainage units (Table 6).

TABLE 6

TOPOGRAPHIC UNITS

(Mapped on Figure 11)

A. Convex Interfluves - or drainage divides
B. Minor Drainage Zones
C. Major Drainage Zones
D. Saline Drainage Zone
E. Tailings Drainage Zone

The majority of the study area comprises the broad, gently sloping convex interfluves. The soils are red earths, with varying proportions and depths of calcareous nodule concentration within the localized drainage zones, which are characterized by broad to braided shallow depressions, generally without well-defined water courses.

Erosion from the existing tailings dumps has created a degraded vegetation zone between the dumps and the saline zone directly draining into Hannan Lake. The area to the north of the tailings dumps represents a considerably disturbed form of the convex interfluve zone.

2.7.2 Vegetation

Two broad vegetation associations were delineated (Table 7).

TABLE 7

VEGETATION ASSOCIATIONS

Eucalypt Woodland

Drainage Shrubland - Broombush type
- Chenopod type
- Succulent type

The woodland zone is dominated by a variety of medium-sized and smaller Eucalypts, with scattered occurrences of Casuarina, Santalam and Pittosperum. Understorey species include Eremophilas, Acacia, Atriplex, Maireana and Triodia.

The vegetation patterns within the drainage zones are determined by the significance of the drainage influence on each particular zone. The lowest levels in the profile have become permanent shrubland, with the association altering with saline influences close to Hannan Lake. Rising in the profile, the shrub zone narrows and, because of the low frequency of moisture in the system, there is a merging with woodland types, with retention of more drainage line tolerant species at the understorey level.

The Broombush type includes species such as Eremophila, Cassia and Acacia. The Chenopod type includes species such as Atriplex and Maireana. The Succulent zone has a restricted species list, the main ones being Frankenia, Atriplex and scattered Maireana.

The zone surrounding the existing tailings dumps originally included woodland and drainage types, however the degree of mechanical disturbance and, in particular, the influence of the erosional material from the dumps has created a very harsh site with a restricted residual community.

2.7.3 Fauna

Faunal habitats are closely aligned with the geomorphological - vegetation zones. The opportunistic field survey (McArthur and Associates, 1987) recorded 20 species of bird, 3 native and 5 introduced mammals, and 3 reptiles. On the basis of literature searches and known habitat preferences, the area has the capacity to support approximately 80 bird species, 20 native and 7 introduced mammals, 4 amphibians and 54 reptiles. The eucalypt woodlands produced the richest faunal assemblages, whilst the saline flats were the poorest.

The region is a transition zone between the wetter south and arid interior, and therefore faunal expression is diverse. As vegetation changes are subtle, and in many cases are very small in comparison to the broad habitats, the variation in species structure is small. Past and present forest operations have created a very uniform woodland with a limited number of standing, or felled, dead material.

None of the species sighted in the field survey, as reported from related studies, is endemic to the region. Two birds and one reptile are gazetted as "rare or otherwise in need of protection" under the Wildlife Conservation Act (1950).

2.7.4 Ecological Significance

The study area is part of geomorphological and vegetation formations which are widely distributed throughout the Kalgoorlie region.

The woodland and minor drainage zones are in good condition, whereas the major drainage zone and large areas of the saline drainage zone have been severely affected by disturbance. The conditions are a reflection of history. The woodland areas were heavily cut-over (clear-felled) in the period 1900-1910, resulting in even-aged stands. More recent regeneration is likely the result of severe fires (eg 1975/76). Firewood and sandalwood removal appears to be regular, although not on a large scale. Geological interest has left the area traversed by many tracks, survey lines, bores, pits and drillholes, whilst the Trans Australian Railway and urban and rural development have been the source for weed introduction in the north and west. A large area is showing significant ecological impact from the tailings erosional material.

The plant site/tailings disposal area is primarily within the Lakeside Reserve (No 19214 - vested in the Conservator of Forests in 1957) which is set aside for sandalwood preservation. The State distribution of sandalwood is wide; at least seven other reserves in the Kalgoorlie region have similar vesting and designation. The sandalwood, in the Lakeside Reserve is not considered to be of exceptional quality, but the reserve is the closest to Kalgoorlie. The field survey found the species lightly scattered over the area, either as individuals or in small, widely spaced groups.

The main significance of the Lakeside Reserve is that it constitutes an attractive woodland zone close to the Kalgoorlie activity centre. It is thus highly desirable that a naturally vegetated buffer zone should be retained around any tailings storage constructed on this site.

The borefield pipeline route traverses a variety of similar topographic units. Installation of the underground pipeline will create minimal impact, however, the overhead powerline may require a wide clearing in woodland areas, and, except where it follows existing cleared easements, will result in some vegetation loss. However, the preferred location of the powerline along existing cleared lines wherever possible will minimize the requirement for clearing.

2.8 Soils

The soils of the existing and proposed tailings sites and environs were investigated on a very broad scale by Northcote et al (1968) who defined two major soil types: red earths (Cn 2.13) with limestone nodules; and alkaline red earths (Gc 1.12).

Field work, which concentrated on the supply line and proposed tailings disposal areas in particular, verified these descriptions and found a close relationship between landform and soil type (Figure 11). Detailed descriptions are presented in McArthur and Associates (1987).

The soils of the tailings disposal area consist of red/brown loams and sandy clay loams of poor to indistinct structure. A limited degree of structure is afforded by understorey vegetation rootlet fabric.

At approximately 200 - 300 mm depth, there is a gradual increase in gravel and clay components giving rise to gravelly, light clays commonly containing calcareous nodules. These are underlain at 1 - 1.5 m depth by sporadically mottled, dry red/brown sandy clays and stiff brown clays.

Hard fractured pink sandstone was encountered at 1 m depth in a test pit on the south-eastern edge of the tailings disposal area.

Between 0.2 and 0.5 m depth of soil material across the tailings disposal area is physically suitable as "topsoil" for removal, stockpile and subsequent replacement as a cover material on the final embankments.

The soils beneath the existing tailings dumps were not investigated due to their limited accessibility (a few drillhole intersections). Following the removal of the dumps, the soils will be fully characterized for the purpose of determining the best procedure for their progressive rehabilitation.

2.9 Land Use

The land in the immediate area of the existing tailings dumps and the proposed plant and tailings disposal site is primarily Vacant Crown Land, Common Land and Timber Reserve, as shown on Overlays A and E. The surburban area of Boulder lies to the west and north of the existing dumps. Pastoral leases surround the project area to the north-east, east and south. A very small proportion of the land in the area outside the township is privately owned, however the project will not directly overlie any private land.

The three major pastoral leases to the south-east of Kalgoorlie and Boulder are Woolibar Station, Mt Monger Station and Hampton Hill Station.

Virtually all land in and around the project area is pegged by mining tenements (Overlays B and F). Much of this land is considered highly prospective, and is tightly held. Anglo American Pacific owns Licence M 26/82 and the LTTs listed in Table 1, however the remaining mineral tenements are held by other companies. The impact on tenements owned by other companies will be restricted to service routes, such as slurry lines, power, water and roads. Permission will be obtained from the current tenement-holders before any activity takes place on their tenements.

The proposed site of the plant and tailings disposal area has been pegged by a 465 ha Mining Lease, M 26/82, 420 ha of which is located within the 3787 ha Lakeside Timber Reserve. Lease M 26/82 has a number of conditions on mining activities including several specific conditions related to its status as a timber reserve (Appendix A). This site has been selected as the preferred site for the plant and tailings disposal area after careful consideration of a range of alternatives.

2.10 Aboriginal Sites

As required under the Aboriginal Heritage Act (1972-1980), a preliminary investigation for traditional Aboriginal sites has been carried out. Correspondence with the Western Australian Museum and Mr R H Pearce in connection with Aboriginal usage of the land under study is reproduced in Appendices B to D.

There are no registered sites within the study area.

A limited site inspection was carried out in association with the soils, flora and fauna survey and no significant artifacts or structures were noted. Drainage lines and ridge zones were inspected.

A review of literature and general knowledge of the ethnographic conditions indicates that the potential for sites in the area is low. The Aboriginal population was sparse and nomadic, and activities centred around water availability. The study area has no permanent fresh water and consequently, although the woodland zones would have been part of a hunting territory, there is low likelihood that any significant camping sites would be found.

Prior to commencement of any earthworks, a systematic sites survey and Aboriginal community interviews will be carried out, to comply with the requirements of the Aboriginal Heritage Act.

3. PROJECT DESCRIPTION

3.1 Mining (Reclamation)

The proposed reclamation system will be hydraulic mining via dual high pressure (3 MPa) monitor guns, with a third standby monitor available for continuity of mining. The monitor control and pump station (Figures 12 and 13), along with associated support facilities, will be relocated once during the life of the project. Civil preparations, including foundation construction, will be made prior to the end of life of the first station to reduce the expected changeover period to less than seven (7) days.

The reclamation will operate on a continuous basis day and night. Mining of each dump will continue until the ground surface is reached. Experience at ERGO (South Africa) has shown that an hydraulic monitor will remove only a minimal quantity of the original surface because the ground has been compacted by the mass of tailings dumps above. Site investigations have been carried out twice to map the original surface, firstly, by logging drillholes and, secondly, by probing methods.

After monitoring, however, some residual slimes will remain. In order to ensure effective rehabilitation of the site, the residual slimes need to be removed. This will be achieved by mechanical means (eg scrapers, loaders and trucks). The original ground surface will not be significantly altered during mechanical cleanup operations, except with approval of underlying tenement holders.

The underlying "soil" is not expected to have retained any useful soil properties, having been compacted and leached of most of the essential elements required for effective vegetative rehabilitation. Hence, upon mechanical clearing of the residual slimes, it is proposed to rip the site on contour (to control runoff), and then determine the soil nutrient requirements, such that a soil revitalization programme can be carried out.

3.2 Ore Processing

On slurrying by the high pressure water jets of the monitor guns, the reclaimed tailings will flow by gravity to the monitor pump station where coarse screening at 3 mm will remove oversize particles and trash material. All oversize and trash material will be transferred to a temporary stockpile prior to periodic removal by road transport and disposal into the new tailings storage. The screened slurry will be pumped through a 350 mm internal diameter aboveground pipeline to the central plant.

At the central plant (Figure 14), the reclaimed material will be thickened, rescreened to remove all material greater than 600 μm average diameter with the undersize (99.6% of the mass) flowing by gravity to the first of six (6) leach tanks. The oversize material will gravitate to the tailings discharge.

Gold recovery will be achieved by the carbon adsorption process (Figure 15) in six (6) mechanically agitated vessels, each of 650 m^3 capacity. Loaded carbon containing gold (up to 500 g/t) will be removed regularly from the carbon-in-pulp vessels and transferred to a gold elution circuit. The rate of carbon movement is expected to be of the order of 10 tpd.

The final gold recovery (carbon elution) circuit will operate using the patented Anglo American Research Laboratories Elution Procedure and gold bullion will be recovered via electrolytic deposition from the resultant eluate.

To maintain high activity levels for the carbon, appropriate acid washing and thermal regeneration methods will be used prior to returning the carbon to the adsorption circuit.

All waste products will be returned to various parts of the circuit with ultimate disposal to the new tailings storage to eliminate the need for separate disposal sites.

3.3 Tailings Disposal

3.3.1 General Description

The project will generate up to 12 000 t of tailings per day and up to 4.2 Mt per annum. The total tonnage of tailings to be treated and stored will be at least 32.5 Mt, but possibly as high as 57 Mt. The significant beneficial effect of the project will be to amalgamate a large percentage of the tailings currently held in various small and large dumps into a single engineered storage, which will provide for environmentally secure storage into the future.

The tailings will be virtually unchanged in grade (particle size distribution) from that currently existing. The process design does not include a grinding circuit and the amount of attrition due to mixing in leach vessels will be minimal.

The tailings will be pumped to the storage in slurry form through a large diameter pipeline and distributed into the storage in a controlled manner. Water released from the tailings will be returned to the plant for reuse. The rate of water return will vary seasonally from approximately 15% in January to approximately 40% in July (Figure 16).

The peripheral embankments will be progressively raised over the life of the project. Stable cover material will be placed progressively to ensure that wind and water erosion is minimized.

3.3.2 Site Selection

The principal criteria for site selection for the new tailings storage are as follows:

. land availability
- current and future land use
- mineral tenement ownership

. hydrological
- peak flood level
- active drainage

. technical
- stability of tailings storage
- area required

. environmental
- ecological
- aesthetic
- downstream effects

. economic

The project is close to Kalgoorlie-Boulder, and already much of the land nearby is committed to a range of land uses. These are principally (Department of Mines, 1988):

. town sites;

. mining zone (incorporating existing mining operations and the proposed "big pit" developments);

. waste disposal zone (principally for the proposed "big pit" developments);

. parklands, timber and recreation reserves;

. aboriginal reserves;

. railway and railway reserves.

These are shown on Figure 17. Clearly the only areas not currently subject to a land use which would preclude the disposal of tailings for this project lie to the south and east. These areas form an arc commencing south of Kalgoorlie-Boulder (west of Celebration Road) extending eastwards across the northern end of Hannan Lake, (south of the existing dumps) then eastwards to the Trans Australia Railway and beyond (east and north-east of the dumps).

All potential disposal sites within this "uncommitted" zone were considered. The evaluation was made with the aid of a method proposed by Caldwell and Robertson (1983) for selection of tailings storage sites. This method involves a 7-stage process, as follows:

TABLE 8

STAGES IN THE SELECTION OF A TAILINGS STORAGE AREA

(Caldwell and Robertson, 1983)

1. Regional screening
2. Site identification
3. Fatal flaw analysis
4. Investigation of sites
5. Qualitative evaluation and ranking
6. Semi-quantitative evaluation and ranking
7. Detailed investigation

Caldwell and Robertson present a number of case studies where this method has been employed, and these studies have been used as a guide for the application of the method to KALTAILS.

There is little flexibility in locating the proposed tailings disposal site in a regional sense due to the need to locate the treatment plant and new tailings storage reasonably close to the existing dumps. The cost of slurry pipeline construction and operating (pumping) costs to transport the reclaimed tailings to the plant together constitute a major cost to the project. To indicate the impact of this cost on the project contours of increasing cost with distance and elevation are shown on Figure 17. These contours represent approximately the combined cost of slurry pipeline construction, plus the estimated cost of the total energy requirement to pump the tailings slurry from the reclamation "focal point" to a treatment plant, over the total project life, taking account of both static lift and friction head losses in the slurry line. There is thus an obvious need to locate the treatment plant and new tailings storage as close as practicable to the existing dumps, to minimise the slurry pumping costs.

Virtually all of the land which is potentially available from a current or future land use perspective is held under mineral tenements. Apart from the LTT's themselves, the only tenement within the project area held by the proponent is mining lease M 26/82. All other tenements, including those underlying the LTT's, are held by other companies not associated with the proponent.

Apart from the land use/land ownership constraints, the most significant factor which limits the choice of site is the hydrological constraint. In order to ensure long-term stability of the new tailings storage, it is necessary to avoid sites located in a major active drainage zone or below the likely peak flood level of 330 m AHD. This area is delineated on Figure 17.

Taking into account the above general constraints, the final site selection for the new tailings storage was achieved by applying Caldwell and Robertson's site selection method to six sites which typify the currently "uncommitted" area to the south, south-east and east of the existing dumps (Table 9). Two additional options have been considered as well (Table 9), viz integration of the tailings storage into NKML's proposed big pit waste disposal area (shown as Waste Zone on Figure 17) and deposition into mined out open pits along the Golden Mile.

TABLE 9

ALTERNATIVE PLANT AND TAILINGS STORAGE SITES

Site Number	Name	Description
1	"West of Celebration Road"	Timbered area south of Kalgoorlie/Boulder west of Celebration Road.
2	"Cemetery Area"	South of Kalgoorlie/Boulder, east of Celebration Road, near cemetery and sewerage plant.
3	"Common"	Common area immediately south of the existing dumps.
4	"Edge of Lake"	Edge of Hannan Lake.
5	"M 26/82"	Mining Lease M 26/82, in Lakeside Timber Reserve.
6	"North-east of Railway"	Timbered area on the NE side of the railway.
7	"NKML Waste Zone"	North of existing dumps, near North Kalgurli Mines Limited mining operations.
8	"Open Pits"	Open pits around Kalgoorlie and Boulder.

A fatal flaw analysis (after Caldwell and Robertson, 1983) has been applied to the eight alternative sites, which are shown on Figure 17. The fatal flaw analysis (Table 10) uses screening criteria to eliminate sites which have characteristics that are sufficiently unfavourable or severe to preclude the use of the site.

TABLE 10

FATAL FLAW SCREENING CRITERIA FOR

ALTERNATIVE TAILINGS SITES

(Caldwell and Robertson, 1983)

VISUAL

1. Unacceptable visual impact

LAND USE/ECOLOGICAL

1. Endangered species
2. Critical wildlife or fish habitat
3. Sensitive or unique ecosystem
4. Important recreation area
5. Historical and archaeological sites
6. Mineralization (economic)
7. Man-made features, eg oil wells or pipelines
8. Land with high agricultural potential
9. Actual or potential urban areas

AIRBORNE RELEASE

1. Dust/erosion - high wind exposure
2. Proximity to human habitation

SEEPAGE RELEASE

1. Foundation (unsuitable for placed liner or as a natural liner)
2. Groundwater discharge area
3. Flood plain

STABILITY RELEASE

1. Topography (too steep)
2. Faults (active)
3. Upstream drainage area (too large)
4. Foundation conditions (poor)

OPERATIONAL

1. Capacity (too small)
2. Access (too difficult)
3. Technical feasibility (not implementable)

COST

1. Develoment cost (uneconomic project)

The fatal flaw screening eliminates Site 3, which is in the open area to the south of the existing dumps, on the basis of the visual and the dust/erosion criteria. The exising dumps are a major cause of serious dust pollution in the residential areas of Kalgoorlie and Boulder. These communities are keen to have the existing dumps treated and removed so that the dust levels can be reduced.

Therefore, Site 3, which has no wind protection and is close to the residential areas, is considered to be unacceptable. It is also unlikely that vegetation could be established on the surface of the new tailings storage in this exposed position. Site 3 also partly overlaps the area considered to be subject to flooding (below the 330 m contour).

The site adjacent to Hannan Lake (Site 4) was eliminated on the basis of the flood plain criterion, and also due to its location along strike from the main zone of mineralization in the area, which causes this site to be viewed as prospective for economic gold occurrence. The area is more than 10 m below the assumed flood line and, although protective embankments could be constructed, there is always the possibility of a breach during a flood, through destabilization of the embankments, in which case tailings could contaminate a very large area below the flood line.

Site 2 is likewise eliminated from the flood plain criterion. It is located on the margin of the flood zone, and there is insufficient area between the 330 m contour and Celebration Road to accommodate the 320 ha plant and tailings disposal site.

The option of making use of old pits (Option 8) would appear to be attractive environmentally, if it were viable. However, the nature of the Big Pit development, and the need to maintain access to possible future underground workings precludes any extensive backfilling with waste rock or tailings (Department of Mines, 1988). This option is thus eliminated by the mineralization criterion.

Finally, Site 7 has been found to be unavailable. NKML has advised that its Waste Zone is barely adequate for its own waste disposal needs, which will occupy a large area due to the height restriction of 40 m imposed by the proximity of Kalgoorlie Airport. NKML is unable to make available from this Waste Zone the 320 ha which would be required for the Kaltails project.

A visual inspection was made of each of the three remaining sites and the advantages and disadvantages of each site were assessed qualitatively. All sites are in timbered land which lies well above the flood line. The main areas where the sites differ are proximity to the existing dumps and to Boulder, access, status of the land, drainage and mineral wealth.

Site 1, west of Celebration Road, is in a lightly timbered area which is classified as a parklands reserve. The site is about 4 km from the focal point of the existing dumps, however, it is closer to Boulder than the existing dumps, being immediately adjacent to the Boulder township boundary, and less than 2 km from the present residential area. Mineralization in this area is not expected to be as high as in the Hannan Lake area, however, there is an abandoned mine which suggests that there is a high probability that potentially economic gold reserves would underlie the site.

Site 5, on M 26/82, typifies the region between the drainage line east of Kalgoorlie-Boulder, and the Trans Australian Railway line. Most of this area is taken up by the Lakeside Reserve, which is the nearest Sandalwood Reserve to Kalgoorlie and Boulder. Most of M 26/82 lies inside this reserve. This site has the most favourable position in relation to the existing dumps and it is also more than 5 km from residential areas. An important advantage of this site is that Anglo American Pacific Limited holds the mining lease and this is the only mining lease it holds in the region.

Site 6 is a timbered area of pastoral lease on the north-east side of the Trans Australian Railway line. This site is attractive because it is in a timbered area which does not have the status of a reserve. It has the disadvantage that slurry would have to be pumped about 5 km from the focal point of operations and this would involve a crossing of the Trans Australian Railway, as well as an additional 30 m pumping lift to the site. Consequently, the cost of slurry pumps over the life of the project would be some $3 million higher than Site 5. It is also in the area of the Casino Project, which is currently under active exploration by Money Mining NL.

These advantages and disadvantages have been assessed semi-quantitatively in Table 11. Site 7, the NKML Waste Zone, although it is unavailable, has been included in this analysis for comparison.

The semi-quantitative assessment indicates that Site 5, on M 26/82, is preferable because it appears to have the minimum impact score. However, the margin in points between the three sites is small and is dependent upon a system of points allocation which has a subjective component. In addition, the points tally system is not weighted to take into account the relative seriousness of the various impacts. There must be a substantial difference in the total ratings for a site to be eliminated or chosen on this basis alone. Therefore, a more detailed investigation was made of all four sites to determine whether Site 5, on M 26/82, is also favourable from a cost point of view (Table 12).

It was assumed in the cost evaluation that the compensation rate for clearing in the Sandalwood Reserve (Site 5) will be $1150 per hectare, although this rate has yet to be finalized. Anglo American Pacific Limited holds a mining lease only on Site 5. There will be considerable cost incurred in obtaining leases elsewhere because of the very tight mineral tenement holding and the high value placed on mineral property in the Kalgoorlie - Boulder area. The cost of these leases has been estimated from information on expenditure by companies in the area.

The costs for slurry pipeline and pumping costs were compared on two bases, firstly capital minimization and, secondly, minimization of operating costs. The first involves using smaller pipe sizes, to maintain similar slurry velocities, while the latter involves using larger pipe sizes and lower flow velocities for the more distant options. The overall cost comparisons between these two bases were in close agreement (within 2% for each alternative site). The adoption of larger pipe sizes for more distant sites was slightly lower in cost (less than 2%), so this basis has been adopted in the cost comparisons of Table 12.

In summary, all stages of the Caldwell and Robertson method for assessment of tailings storage sites have been completed. Four sites were eliminated because they involved very high environmental impacts, known in the method as "fatal flaws". The remaining four sites all involved lesser impacts on the environment and these impacts were compared using a semi-quantitative evaluation and ranking. One of these sites (the NKML Waste Zone) has been found to be unavailable.

This system indicated that Site 5 (M 26/82) had the most favourable assessment rating. The four sites were then studied in more detail and total project costs were determined for each of the sites. Site 5, on M 26/82, was also the most economically attractive site. This is particularly important for this project since the profit margin is close to the market return on investment, and therefore a more expensive site would seriously jeopardize the viability of the project.

TABLE 11

SEMI-QUANTITATIVE ASSESSMENT OF ALTERNATIVE TAILINGS SITES

Ratings: Low impact 0
Medium impact 1
Adverse impact 2

Criteria	Site 1 - west of Celebration Road	Site 5 - M 26/82	Site 6 - NE of Railway	Site 7 - NKML Waste Zone
VISUAL				
1. Visual impact	1	0	0	1
LAND USE/ECOLOGICAL				
1. Endangered species	0	0	0	0
2. Wildlife or fish habitat	0	0	0	0
3. Ecosystem	0	0	0	0
4. Recreation area	1	2	0	0
5. Historical or archaeological value	0	0	0	0
6. Mineralization	1	0	1	0
7. Man-made features	0	0	0	0
8. Agricultural potential	1	0	1	0
9. Actual or potential urban area	0	0	0	0
10. Forestry	0	2	0	0
AIRBORNE RELEASE				
1. Dust/erosion problems	1	0	0	1
2. Proximity to human habitation	2	0	0	1
SEEPAGE RELEASE				
1. Foundation permeability	0	0	0	0
2. Groundwater discharge area	0	0	0	0
3. Flood problems	0	0	0	0
STABILITY RELEASE				
1. Topography	0	0	0	0
2. Faults	0	0	0	0
3. Drainage	0	1	1	0
4. Foundation conditions	0	0	0	0
OPERATIONAL				
1. Capacity	0	0	0	0
2. Access	0	0	1	0
3. Technical feasibility	0	0	0	0
COST				
1. Development cost	1	0	2	2
TOTAL	8	5	6	5

TABLE 12

RELATIVE COSTS FOR ALTERNATE SITES*

$ millions

Item	Site 1 - west of Celebration Road	Site 5 - M 26/82	Site 6 NE of Railway	Site 7 - NKML Waste Zone
1987/88 capital	1.00	1.00	1.00	1.00
Plant, access	1.00	1.00	1.00	1.00
Water supply	1.00	1.00	1.00	1.00
Tailings storage and slurry pipeline	1.23	1.00	1.50	1.41
Present worth of pumping costs	1.29	1.00	1.61	1.39
Compensation** or estimated cost of acquiring leases	1.86	1.00	1.86	4.04
TOTAL* **	**1.05**	**1.00**	**1.10**	**1.10**

* All costs have been determined relative to site 5, which is the preferred option from Table 11.

** Subject of current discussions.

***Total costs include only initial capital expenditure and pumping costs throughout the life of the project.

3.3.3 Chosen Site

As described elsewhere, the chosen Site 5 on M 26/82 is classified as part Timber Reserve and part Vacant Crown Land. The site is gently sloping from the north-east corner towards the south-west, with a total fall across the site of approximately 13 m.

The site is crossed by several streams which originate from catchments on the northern side of the Trans Australian Railway line. The streams flow generally in a south-westerly direction. A preliminary site investigation shows that the site is covered by a relatively uniform layer of silty, clayey gravels overlying clay, which in turn overlies completely weathered bedrock. The permeability of the foundation areas is expected to be low.

The site will provide the source of materials to be used in the construction of the initial or starter embankments. The weathered bedrock will be rippable to a reasonable depth and, as such, will provide for the development of economic borrow pits. The formation of the borrow pits will not be detrimental to the security of the site in terms of seepage control.

The more permeable gravels which can be found in the drainage channels are likely to be incorporated into an "upstream" drainage blanket within the storage, which will assist in improving the drainage of the tailings adjacent to the embankment. The details of such a drain, including outfall pipework, will be determined at final design stage.

3.3.4 Nature of the Tailings

The tailings will be virtually unchanged in particle size grading from those presently contained in the various small and large dumps. There will, however, be a change in the level of salts trapped with the tailings due to the use of hypersaline bore water in the reclamation and transportation of the tailings, although many of the dumps are already high in salt, residual from previous treatment.

The coarse tailings can be classified as a fine sand and, as such, possess high internal strength but almost zero real cohesion. The fine fraction of the tailings can be classified as a silt. As such, the confined strength of the material can be quite high, especially at low moisture content.

The tailings in the existing dumps are generally segregated in terms of particle size, with the more coarse fraction being towards the outer edge of the dumps and the fines towards the centre. During remining and treatment, the tailings will be remixed to provide a relatively uniform grade for processing. At the new tailings storage, the deposition system will promote segregation once again so that the coarse, more readily draining fraction lies against the periphery of the storage. This coarse fraction will be used in the construction of successive lifts of the outer embankments.

The tailings, once deposited into the storage, are expected to be relatively stable against saltation (wind erosion) due to the combination of contained moisture and salt crusting. The tailings in the outer embankments will display apparent cohesion due to negative pore pressure development and a certain amount of "cementation" due to the high salinity of the process water.

The tailings liquor will contain some residual cyanide and traces of chemicals such as lime. The cyanide levels in both the tailings and the released liquor will be low and the major portion will be volatilized rapidly on the broad beach areas and from the ponds around the decant towers.

3.3.5 Tailings Storage Design

The proposed tailings storage will occupy an area of approximately 250 ha (internal) or 290 ha (external). The storage will be 1400 m x 1800 m, as measured from the upstream crest of the initial peripheral embankment.

A single storage with a rectangular shape is proposed as a compromise between efficient cost-effective construction and efficient utilization of the available site with minimal environmental disturbance. The most cost-efficient construction involves a storage which maximizes storage volume per unit volume of embankment fill material. Thus, in theory, for a level site, a circular tailings dam would be preferred, however in practice, for ease of construction, pipework layout and maintenance, an approximately square shape is adopted as the most cost-efficient. The use of triangular or irregular-shaped storages, or the use of several separate smaller storages, adds significantly to construction cost by the requirement for additional construction material.

In this case, an approximately square, rectangular shape has been adopted to make optimum use of the less heavily timbered southern part of the lease (M 26/82), with provision also for the plant site, topsoil stockpiles, temporary waste stockpile and other necessary activities close to the least environmentally-sensitive southern boundary.

The basic philosophy behind the design is to provide a storage which will be easily manageable throughout the project life and which will have minimal impact in the longer term on the immediate environment. The latter condition requires that the storage satisfies certain engineering criteria with respect to stability of embankments and containment of waste water. The storage will be a "referable dam" and its design will be subject to approval by the Water Authority under the terms of the Rights in Water and Irrigation Act.

The capacity of the storage will be progressively increased over the life of the project by raising the outer embankments in an upstream direction using excavated coarse tailings (Figure 18). The methods to be used to both manage the storage and raise the embankments are based on well proven techniques developed many years ago for construction of tailings storages in an arid environment. The basic differences between the methods in use today (and proposed for this storage) and those used up to the early 1960's is that the embankment lifts are constructed using machine excavated material, rather than hand excavated, and the overall slope angle of the downstream faces of the embankments is considerably flatter.

The storage for the first six to twelve months of production will be provided by earthfill embankments constructed from selected fill obtained from within the basin and from the drainage diversion channels. Because of the slope across the site, the initial embankments will be higher towards the southern side of the storage and will run out into the natural surface before forming a continuous crest. The embankments will be completed during the latter part of the initial year of the operation.

The initial embankments will provide for the secure containment of the first year's production of tailings, estimated to be around 4.2 Mt. Thereafter, the embankments will be raised by around 2 m per year.

Preparation beneath the proposed embankments will include the excavation of a cutoff trench through the more permeable sand/gravel channels. The cutoff will be carried down to the underlying clays and then backfilled and compacted with gravel/clay of low permeability.

The proposed starter embankment will similarly be constructed from clay/gravels excavated within the storage area, placed in layers and compacted.

The slopes of the faces of the embankments will be 3 horizontal to 1 vertical downstream and 2 horizontal to 1 vertical upstream. With 5 m berms at each lift, an overall slope angle of 4 to 1 will be developed. The downstream face will be flattened by the addition of a waste rock cover during the progressive decommissioning of the embankments.

During excavation of fill within the storage, the borrow area will be contoured to facilitate drainage to the initial decant. The more permeable gravels won from within the storage area will be spread adjacent to the upstream toe within the southern part of the storage. This will encourage the drainage of the tailings and lowering of the phreatic surface. Water collected adjacent to the embankment will be directed to a sump located beyond the downstream toe of the embankment and returned to the plant water circuit.

Along the northern and eastern boundaries of the storage, channels will be constructed to divert flood waters around the site. Excavated material will be used to construct a bund between the downstream toe of the proposed embankment and the diversion channel. The bund and the exposed north-western portion of the tailings storage embankment will be appropriately armoured as necessary to resist erosion.

The tailings will be pumped to the storage from the plant via a large diameter pipeline laid in a bunded trench to contain slurry in case of a pipe failure. A system of distribution pipework placed on the crest will be used to control the discharge of tailings into the storage so that long beaches are formed sloping towards the decant towers. The controlled discharge of tailings will result in the majority of the coarse material remaining close to the embankments. The fines and the released water will flow down the beach, the water ponding around fixed decant positions.

Water recovery from the tailings storage will be maximized at all times. Each decant will consist of a vertical riser, surrounded by waste rock, leading to a gravity outfall pipe which passes beneath the embankment. The outfall pipes will gravitate reclaim water to the plant water storage dam prior to being delivered back to the plant circuit by pumping. The plant water storage dam will be lined to prevent seepage. The rate of water recovery will be controlled by raising or lowering the effective decant intake level using collars. Access to the decant towers will be via rockfill causeways which will be raised as the peripheral embankments are raised.

Seepage from the tailings storage will be minimal. The foundations comprise hard clay gravels of low permeability. The deposited tailings will be allowed to air dry to achieve high density and hence low permeability. Use will be made of underdrains around each decant and adjacent to the deepest sections of the embankment to provide a preferential flow path for the small volumes of water which will drain through the tailings (Figure 19). Water collected by the underdrains will be returned to the plant.

3.3.6 Ongoing Management

The capacity of the tailings storage will be increased progressively during the life of the project by constructing a series of upstream lifts of the peripheral embankments. These lifts will use coarse tailings excavated from the drying tailings beaches as fill material. Each major lift will comprise two smaller lifts of approximately 1.5 m. Berms will be left at each major lift and, as a result, the overall outer (downstream face) slope will be around 4 horizontal to 1 vertical.

The tailings will be excavated and compacted to form stable bunds which will provide for light vehicle access and pipe support. Experience at other sites, where similar tailings are encountered, has shown that, providing the tailings are at the correct moisture content, the material can be readily compacted to form a dense fill not subject to continued settlement. It will, however, be essential that the storage be managed to ensure that the free water pond is kept remote from the embankments at all times.

It is proposed to progressively cover the downstream face of the peripheral embankments with stable waste rock as each new lift is formed. The waste rock will be sourced from one of the many stockpiles of waste taken from the open pit mining operations on the eastern edge of the Kalgoorlie/Boulder township. A description of the proposed decommissioning methods is provided in Section 5.8.

The storage will be managed at all times to maintain adequate freeboard for normal tailings discharge and to contain the rainfall which would result from a long return period 72 hour rainfall event. The tailings beaches will slope away from the embankments at an expected grade of around 1 in 150 (conservatively estimated), thus creating a dish effect within the basin. A dish will be formed around each decant position. As the demand for makeup water at the plant will be high at all times (with the exception of maintenance shutdowns), the pond around each decant will be small in extent and the capacity for rainfall storage will be great. A probable maximum rainfall event of 860 mm in 72 hours, which was determined by the Bureau of Meteorology (1987), will be readily contained within the storage and still leave at least 0.8 m of freeboard below crest level under the worst conditions in which there is no withdrawal to the plant.

As the water level rises, the effective intake level at the decants will be raised to ensure that the outflow matches the plant water requirements.

3.3.7 Monitoring

It is proposed that the performance of the tailings storage be closely monitored throughout the project life. Monitoring systems will include the following:

- Piezometers in the peripheral embankments and in the foundations to measure phreatic surface levels and groundwater pressure heads
- Settlement gauges in the embankments
- Measurement of recovered water quantity and quality
- Regular sampling of the tailings used in embankment construction, including laboratory determination of insitu strength
- Regular surveys of the embankments and beach levels to enable overall performance to be measured

- Measurement of windblown dust levels, including one year of baseline measurement
- Monitoring bores in selected locations downstream of the storage to enable groundwater sampling to be carried out on a regular basis, including one year of baseline measurement
- Recording and reporting of bird activity in the tailings storage.

The stability and overall performance of the storage will be regularly reviewed by an independent and qualified firm of consultants to enable accurate, periodic reporting, as required.

3.4 Water Supply

The water supply will be obtained from groundwater resources to the south-east of the proposed plant site/tailings disposal area. The proposed source aquifer is a channel sand deposit in the base of a prominent paleodrainage which flows in a general easterly direction to the south of the site.

The aquifer comprises sands with gradations to gravel and silt, which occurs as a continuous, meandering channel deposit at a depth of between 30 and 70 m or more below ground surface. It is overlain by an extensive, tight clay sequence, which acts as a confining layer.

This aquifer system is currently used for water supply to several projects in the region, including the following in the KALTAILS catchment -

- North Kalgurli Mines Ltd, Fimiston plant - 1000 kL/d
- Croesus Mining NL, Hannan South project - 200 kL/d
- AUR NL, Mt Martin project - 600 kL/d
- Newmont Holdings Pty Ltd, New Celebration project - 2000 kL/d
- Hampton Australia Ltd, Jubilee project - 2000 kL/d.

The first two borefields are located on a tributary paleochannel which passes immediately south of the KALTAILS project site, while the latter three are situated on a southern tributary.

The water supply borefield is expected to eventually comprise approximately 21 production bores. It is proposed to initially develop 15 bores, each with average yields of 800 kL/d. There will be 5 standby bores which will be periodically rotated, however, all 15 bores will be required to meet the peak demand. During the project life, six new replacement bores will be commissioned, each with a capacity of 1600 kL/d. The replacement bores will be located further to the east, downstream of the confluence between the two paleochannel tributaries, where the thickness in the paleochannel aquifer is approximately doubled.

The bores will be located approximately at 1.3 km intervals along the developed length of the paleochannel aquifer. The precise locations, depths and design installed capacities of individual bores will be determined from drilling and testing during the construction period.

The production bores will be constructed of fibreglass reinforced plastic (FRP) casing with in-line screens of 316 stainless steel, and gravel packed. The bores will be equipped with 316 stainless steel submersible pumps, fitted with controls for pump and motor protection, semi-automated operation and monitoring. Power supply will be reticulated to each site by overhead powerline, with a step-down transformer adjacent to each bore.

A trunk pipeline will be installed along the borefield. This will be constructed of non-corrosive materials (polyethylene or other thermoplastic) and will be buried beneath a minimum cover of 300 mm throughout its length to a 40 000 kL lined storage dam at the plant site. Appropriate isolation valves and scour valves (with adjacent sumps for containing the saline water discharged) will be installed along the pipeline route. The route of the buried pipe will be marked by signposts at not more than 100 m intervals. An adjacent all-weather access track will be constructed along the pipeline route.

Exploratory drilling has shown that the water quality is within the following range -

TDS	90 000 - 120 000 mg/L
pH	3.5 - 8
sodium	30 000 - 40 000 mg/L
magnesium	3 500 - 5 000 mg/L
chloride	50 000 - 60 000 mg/L
sulphate	5 000 - 9 000 mg/L

This is similar to water qualities of other existing supplies in this aquifer system.

A numerical finite difference groundwater flow model has been used to simulate the effect of the proposed abstraction on groundwater levels within the aquifer, and the effects on other users. The model grid has been set up over the aquifer system within the known extent of its occurrence, extending approximately 30 km upstream from the borefield and 20 km downstream in the northern tributary, and for a distance of 50 km upstream from the confluence in the southern tributary. The paleochannel certainly extends considerably further both upstream and downstream, particularly downstream to the east, where the channel is believed to continue all the way to the Eucla Basin, 200 km away. The borefield abstractions have been simulated by discharge from cells underlying each of the existing borefields, as well as the proposed KALTAILS borefield. The model simulation has been run for a period of 14 years resulting in a predicted aquifer dewatering of between 10 and 13 m through the KALTAILS borefield area, with no deleterious interference with any of the existing borefields (Australian Groundwater Consultants, 1987c).

Monitoring bores will be constructed at appropriate intervals along the paleochannel aquifer, both within the borefield area, and beyond its extremities, to enable progressive monitoring of groundwater levels during operation of the borefield, and to enable the depletion and recharge aspects of the resource to be determined.

The proponent holds current Groundwater Licences from the Water Authority of Western Australia (21193 and 21194) to carry out exploratory drilling in the proposed development area. An application has been lodged with WAWA for a Groundwater Extraction Licence for the project, as required under the Rights in Water and Irrigation Act.

It is anticipated that the quantity of water recovered from the tailings storage will vary between 15 and 40% of the total amount of water pumped to the storage with the tailings. The remaining quantity of water will be either trapped in the tailings or lost by evaporation as the tailings slurry flows over the beaches and from the ponds surrounding the decant towers. Of the water initially trapped in the tailings, most will be later lost by evaporation from the drying surface. Losses by seepage are expected to be minor. Estimated water balances for January and July are shown on Figure 16.

The management of the tailings storage will be directed to the recovery of as much water as possible for several reasons -

- The cost of return water from the storage will be far less than that of makeup from the borefield
- Return water will likely contain some cyanide and alkalinity, and therefore will reduce overall cyanide and lime consumption
- Return water will likely contain some gold in solution which can be recovered in the circuit.

3.5 Sundry Support Facilities

3.5.1 Power System

Power will be received at the plant site via an overhead 33 kV line from the SECWA transmission lines adjacent to the Kambalda Road. Transmission of power to the borefield will be from a control point at the plant site, with transformers located at each bore at approximately 1.3 km intervals. The current plant design requires a total installed power of approximately 7.25 MW with normal operating loads of around 3.8 MW. Particular attention will be paid to power factor correction and harmonic suppression in the power systems. It is not anticipated that standby power will be installed at the plant site, with the exception of emergency backup support for the final gold recovery stage and carbon regeneration unit.

3.5.2 Plant Buildings

The design includes a fully self-contained mechanical workshop for routine maintenance, with specialized work to be undertaken externally by appropriate contractors. An administration building will be constructed on site requiring communications links for telephone, telex and facsimile equipment. Additional facilities will include male and female ablutions, first aid rooms, small laboratory and changerooms.

3.5.3 Housing

Because of the shortage of housing in the Kalgoorlie-Boulder townships, a number of alternatives are being evaluated to comfortably accommodate senior employees who are recruited from outside the local community. Preliminary discussions have taken place with local representatives from the Boulder Shire, the Kalgoorlie Town Council and property developers regarding the housing needs of the Project.

3.6 **Workforce**

The total workforce will be 67 persons, of whom as many as possible will be recruited locally. Of the projected permanent workforce, it is expected to have 18 salaried staff and 49 award employees.

Estimates indicate that the ratio of male to female employees will be of the order of 3.3:1 overall, although there is likely to be a ratio of 1:1 in the salaried staff category.

A breakdown of skill levels indicates -

7	- tertiary qualified
13	- indentured trades
20	- work experienced
7	- higher school technical training
20	- unskilled
67	

3.7 **Corridors**

All service corridors will be constructed according to the specific duty requirements and, where necessary, will provide access by conventional vehicles at all times. Road maintenance, including dust suppression, will normally be conducted by direct labour and company equipment.

3.7.1 Drainage Diversion Channels

The proposed site for the tailings storage and treatment plant is crossed by a series of broad, shallow streambeds which are fed from a catchment north of the Trans Australian Railway line. The streambeds are dry for the majority of the year and only carry flow after a period of intense rainfall. The streams are, however, capable of carrying large flows during long return period rainfall events and must be diverted around the tailings storage.

It is proposed that a major diversion channel be excavated along the northern and eastern sides of the tailings storage to intercept the flow from the various culverts which pass water beneath the railway line. The eastern diversion channel would be continued down the eastern side of the lease in a southerly direction to the southern boundary of the lease area. The diverted water would be discharged to flow downslope toward Hannan Lake. The northern diversion would be taken across to the western lease boundary.

At the north-eastern corner of the storage, flood protection including rock armouring will be provided to ensure that the embankment is stable against erosion. The performance of the diversion channel and flood control works will be closely monitored throughout the project life and modifications made where necessary to ensure that long-term low maintenance diversion of the creek flow can be assured.

3.7.2 Slurry Pipelines

Slurry pipelines from the monitor stations to the plant site and from the plant site to the new storage will be located aboveground, within a bunded channel, to contain any spillage in the event of a pipeline failure. All existing roads or tracks crossing the slurry line route will be reinstated, and additional crossings will be provided in other areas to maintain reasonable access across the pipe.

3.7.3 Borefield Corridor

The pipeline, powerline and borefield access road will be contained within a 20 m wide easement extending from the plant site area along the borefield to its eastern and southern extremities. Wherever possible, this route will follow existing easements or cleared lines, viz -

- from the plant area to the Mt Monger Road (2.1 km), alongside the North Kalgurli Mines Limited pipeline route
- along Mt Monger Road to the south-east for a further 2.5 km
- along a section of an old woodline between 10.7 and 14 km from the plant site.

This route will limit the extent of additional clearing required.

The pipeline will be buried, and its route will be clearly marked at not more than 100 m intervals by labelled signposts.

3.8 Operational Rehabilitation

3.8.1 Introduction

At the commencement of the project, Anglo American Pacific Ltd will appoint a project rehabilitation/environmental officer. The responsibilities of this person will include operational air and water quality monitoring, the design of rehabilitation works, and the conduct of research to select appropriate vegetation species for revegetation operations. Close cooperation with WA Government departmental research officers in Kalgoorlie will be an integral function of the position.

3.8.2 Power and Water Pipeline Corridor

Disturbance to soils and vegetation during the construction and operation of the power and water supply line will be minimized. This will be achieved by the sensible alignment of the line around large trees, the construction of sumps and drains for bore test pumping, and the provision of strategically placed 3 x 2 x 2 m scour sumps along the water supply line for periodic line flushing. Because the water is hypersaline, the drains and sumps will be located away from trees at a distance of at least four times the canopy diameter of the nearest mature tree.

Soils disturbed by the pipe laying operation (blade trench method) will be replaced and raked to encourage shrub growth and the corridor left in a tidy condition. A minimum width maintenance access track will remain alongside the line.

3.8.3 Mined Tailings Dumps

It is intended that the mined tailings dumps will be progressively rehabilitated, however, permission will be required from all underlying tenement holders. At the completion of the mining phase, this will involve the restoration of approximately 300 ha of surface, 272 ha of which was previously overlain by tailings dumps.

Following the removal of each dump, the ground surface will be fully characterized in terms of physical and chemical properties. The soils, to a limited depth, can be expected to be highly saline as a result of past leaching of salts from the tailings, and from the mining method which utilizes hypersaline water.

The surface will have a low slope (1:150), and deep cross-ripping (two directions) at 1 m spacings will both increase infiltration, and therefore profile leaching, and alleviate any potential runoff and erosion problems. The surface will then be armoured with a 35 - 40 mm layer of erosion-resistant cover, such as slag from the local nickel refinery. The 40 mm depth of slag cover has been chosen on the basis that it is well in excess of the 9 mm (200 t/ha) practical working figure adopted by the GDAC (1984), and it will afford long-term protective cover. Nunn (1981) reported some mobilization of slag on the Trafalgar dump, applied at a rate of approximately 215 t/ha. The areas will be left to leach for two or more years, during which time they will be monitored for chemical improvements, and research and trials will have defined an appropriate revegetation programme. This will also have the benefit of the results of significant research and trials currently being conducted by the WA Department of Agriculture in the Goldfields district (Petersen, 1987; Burnside, 1987).

Revegetation of the mined tailings area will be carried out on a trial basis with a number of combinations of salt tolerant species such as Atriplex bunburyana, A sp "Pintharuka", A nummularia, A stipitata (saltbushes), Maireana brevifolia (bluebush), and possibly some of the salt tolerant eucalypts such as E sargentii (salt river mallet), E dundasii (dundas blackbutt) and E myradena (southern cross blackbutt), in addition to specific species that research defines.

The construction of windrows of suitable plant-rooting medium (such as waste rock and overburden) across the surface following the leaching period will provide a favourable seedbed for revegetation operations and further reduce the potential for wind erosion.

In the event that revegetation is unsuccessful, the area will be covered with waste rock or other suitable material to minimize dust production.

3.8.4 Tailings Storage

The tailings storage created by the project will contain up to 57 Mt of tailings and cover an area of approximately 290 ha. At its highest point, the storage will be approximately 26 m (vertical) above pre-existing ground level and have a maximum batter angle of 1:4 - 1:5 and maximum slope lengths of 30 m. The top surface of the storage will have a low slope of approximately 1:150, draining inwards, to the positions used for the central decants during operation.

Progressive rehabilitation of the storage is planned adopting the strategy outlined in Section 5.9.4.

The rehabilitation method involves the creation of structurally stable final batters, covering these with at least 1 m of suitable waste rock followed by a layer of topsoil into which machine mulched vegetation has been incorporated. The purpose of incorporating mulched vegetation (from the clearing process) into topsoil is two-fold. Firstly, it provides a long-term source of organic matter, which is beneficial to soil structure development and in the promotion of soil fauna and fungi, and, secondly, chipped vegetation will provide a source of erosion protection.

Progressive revegetation will be attempted on a trial basis. As the project progresses and significant areas for rehabilitation are created, and the results of AAP and WA Government research projects become available, revegetation will incorporate the direct seeding or planting of native species, probably in combination with application of phosphatic fertilizer at rates of up to 200 kg/ha. In the event that no species with a sufficiently high salt resistance can be found, then the surfaces will be armoured with waste rock to control dust and erosion.

Due to the method of tailings emplacement, rehabilitation of the top surface of the storage will not be possible until the completion of the project. The rehabilitation strategy proposed for this surface is similar to that proposed for the mined tailings dumps (Section 3.8.3), with the deletion of a period for leaching prior to revegetation operations. The centrally grading 1:150 low slopes formed on the top of the storage will be retained. This will preclude runoff from the top of the storage flowing over and down the side batters. The potential for temporary ponding of runoff at the central decant sites is recognized but not considered to be a structural problem as it will not affect the integrity of the storage.

3.8.5 Project Mothballing/Premature Closure

In the event of project closure prior to the treatment of all the dumps proposed, Anglo American Pacific's rehabilitation strategy remains basically unchanged. The rehabilitation programme for reclaimed areas will continue since funds will be continually set aside during the operating periods, allowing for progressive rehabilitation as each area is uncovered. Surface revegetation of the new tailings storage and disturbed areas around the plant site will be the subject of an ongoing programme, also funded by the progressive treatment operations.

The treatment plant, monitor stations and all ancillary infrastructure will be either mothballed and placed under care and maintenance, or removed. Rehabilitation of the mined dumps will proceed as outlined in Sections 3.8.3 and 5.9.5, up to but not including the dump being mined at closure. Rehabilitation of the tailings disposal area will be completed as outlined in Section 5.9.4, up to and including the top batter of the storage. The top surface of the storage will be covered in a layer of slag or similar appropriate material to achieve dust abatement and promote leaching of salts. The decision to proceed with revegetation of the top of the storage will depend upon the period of closure and will be made in consultation with the relevant authorities.

4. BENEFITS OF THE PROJECT

4.1 To The Company

Benefits to the company will primarily be in terms of profits. It is expected that the profit margin will be close to the market return on investment. However, an economic analysis has revealed that an operation of this nature is particularly sensitive to both gold price and operating cost and, therefore, the economic evaluation has been based on a conservative gold price.

Apart from the profit earnings attributed to the project, another benefit to the company is its continued presence in the Golden Mile which can be expected to have flow-on benefits in the developing gold industry.

4.2 To The Community

The benefits of the project to the regional community are several, the foremost being the removal of 272 ha of tailings dumps which are a significant source of dust to the Kalgoorlie and Boulder communities (Richmond et al, 1973). From the existing information, it is not possible to quantify the reduction in wind-borne dust to the Kalgoorlie and Boulder townships. However, by removing approximately four-fifths of the tailings dumps from the Boulder-Lakewood area, a significant reduction in wind-borne dust pollution is predicted.

The project will employ a workforce of 67, the majority of whom are expected to be residents of the Kalgoorlie/Boulder communities.

The effect of the project upon local business is difficult to quantify. However, it will certainly result in increased local trade, with the normal economic benefits to businesses and the community.

By initiating the project, Anglo American Pacific Ltd will set new environmental standards for the region and will create a base upon which such future projects can be modelled. Such improvements to the living standards and aesthetics of the region can be therefore seen as beneficial.

4.3 To The State

By using this project as an example, WA Government authorities can demonstrate recently adopted impetus for the responsible development, operation and decommissioning of mining operations. Research which will be carried out by Anglo American Pacific Ltd on the revegetation of saline dumps should have wider benefit to the mining and farming sectors of the State.

The removal of some of the old tailings dumps reinforces WA Government agency promotion of more responsible mining operations, and allows the more effective promotion of the region as an appealing tourist destination.

5. ENVIRONMENTAL IMPACT AND MANAGEMENT

5.1 Environmental Management

The project will impact on the existing environment in areas of new construction, but will also remove a major source of dust in the Kalgoorlie - Boulder region. Anglo American Pacific Ltd recognizes the importance of the local environment and proposes to minimize any possible adverse impacts. To this end, at the commencement of the project, Anglo American Pacific Ltd will appoint a project rehabilitation/environmental officer. The responsibilities of this person will include operational air and water quality monitoring, the design of rehabilitation works, and the conduct of research to select appropriate vegetation species for revegetation operations. Close cooperation with WA Government departmental research officers in Kalgoorlie will be an integral function of the position.

5.2 Water

The groundwater resources of the region are all saline to hypersaline, and have no beneficial use at the present time other than for gold processing and other mine usage (dust suppression, washing, etc). There are no known resources of potable or stock quality groundwater in the immediate project area.

Abstraction of saline groundwater from the aquifer systems by "mining", or depletion of storage at a rate faster than its natural replenishment by recharge, is permitted by the State in view of the limited usefulness of the resource.

Several gold projects in the Kalgoorlie area rely substantially or solely on the saline groundwater resource, as will KALTAILS. Implementation of KALTAILS will add to the present exploitation of the groundwater resources, however these resources are adequate to meet the needs of all current and probable new projects for at least 10 - 20 years. The entry of a new substantial project, or significant extensions to current planned life of the present projects, could see the need to look further afield for additional water resources, however, there are several sources of groundwater close to Kalgoorlie which will remain available for development for smaller projects.

Exploitation of the saline groundwater resources on a large scale may have a beneficial impact, in allowing for either an increased rate of recharge, or reduction in the rate of loss to evaporation. In either case, this would lead to an improvement in quality of the groundwater in the longer term, although it is unlikely that the water would ever reach potable or stock quality.

Of more obvious benefit is the opportunity that the use of saline water offers in the preservation and appropriate use of the fresh water resource, which is brought to Kalgoorlie via the 600 km Goldfields Pipeline from Mundaring.

Local environmental impacts from the saline water supply will be minimized in the following ways -

- construction of temporary small earthen dams adjacent to each production bore site to contain saline water during drilling and test pumping
- burying of the water supply pipelines
- provision of catch-dams at each scour valve site to contain saline discharges
- provision of isolation valves at regular intervals along the line to minimize the water losses during maintenance and repairs
- regular maintenance checks of the pipelines and control systems to ensure prevention and prompt repair of leaks.

Water reuse will be maximized by employing features of the storage design to ensure optimal recovery of water, including -

- central decants, with tailings disposal controlled to encourage efficent beach development and settling
- the incorporation of a drainage blanket at the upstream toe of the southern peripheral embankment, with a recovery system to intercept seepage and return to the plant water storage dam.

The majority of unrecovered water will be lost by evaporation from the large exposed surface area of the storage, although it can be expected that some small seepage losses will occur. Seepage losses will be minimized by the presence of a low permeability, clayey substrata around 1 - 2 m below the present natural surface, which will assist in containing seepage paths in the surficial material, ensuring the effectiveness of the underdrains.

In the event that some seepage does escape, there are no groundwater or surface water resources either underlying the site or downstream which will be impacted. There is no downstream habitation, or stock dams, between the tailings storage site and the eventual discharge point for the surface runoff, Hannan Lake. The phreatophytic vegetation relies on soil moisture, not groundwater which is highly saline, and it will continue to receive moisture from local infiltration of rainfall and sheetflow runoff as at present.

5.3 Flora and Fauna

The principal impacts from the construction of a major tailings storage in the study area will be the loss of vegetated area and the impositions on the natural land drainage system. The area loss from the storage and facilities (maximum 315 ha, of which 280 ha lies within Lakeside Reserve) is small in comparison to the ecological units represented, and even the size of Lakeside Reserve itself (3787 ha).

The area has already received considerable disturbance (railway lines, power and pipelines, rural intrusions, mining exploration and timber operations) and, as the project development proposal is south of the railway line, secondary impacts through drainage zone risks will be minimal.

There are no significant plant species which are not well represented elsewhere which would be affected by the dam construction.

A tailings storage of the dimensions proposed will necessitate careful consideration of natural drainage implications. The establishment of effective barriers during and after construction is essential. There is ample evidence from the natural environment that destructive erosion can quickly develop with site disturbance. It appears that some form of drainage diversion will be necessary, preferably to the south to minimize impact on broader vegetation types, and reduce the flow distance to Hannan Lake.

The erosion material from the existing tailings dumps has had a drastic effect on the native vegetation. The new tailings storage will ensure secure containment and eliminate escapes and secondary impacts over naturally vegetated areas.

The impact of the project on fauna is generally secondary. There will be major impacts initially with destruction of habitat and relocation into neighbouring habitats. Overpopulation will occur and natural forces will operate causing population levels to reach a balance according to the availability of food and water satisfactory to sustain each community. These impacts will be minimized by staging clearing, limiting clearing to the absolute essential minimum, efficient disposal of wastes, fencing off dangerous areas, limiting road and track development, installing below-ground services and rapid rehabilitation with local species.

Some bird mortality is expected to occur during the project life as a result of birds gaining access to open water surfaces on the new tailings storage.

5.4 Waste Products

5.4.1 "Oversize" and "Junk"

Approximately 1% of the tailings reclaimed will be screened out as "oversize" waste. In addition, an unknown quantity of "junk" (steel, timber, etc) will be recovered. "Oversize" waste will be transferred to a temporary stockpile adjacent to the monitor station, and periodically transferred by road to a permanent stockpile near the plant site.

Any scrap metal or timber with a commercial value will be salvaged, and the remaining "junk" will be transferred periodically for disposal into the new tailings storage, or to a Shire-designated dump. The ultimate destination of the junk will be dependent on the quantity recovered.

The oversize dump will be built up progressively during the life of the project, and will be used as a source of material for progressive rehabilitation and in the final decommissioning cover of the tailings storage.

5.4.2 Cyanide Decay

The cyanide content (as CN^-) of the tailings solution as it enters the tailings storage is expected to be of the order of 0.005 to 0.01% (50 -100 mg/L CN^-). Because of the alkaline nature of the solution, CN^- will be the dominant species (more than 95% of total cyanide). Free cyanide is highly reactive and is therefore quickly either degraded or fixed in metallo-cyanide complexes. It is the latter case that is of most environmental concern because the longer-term dissociation of cyanide complexes can release free cyanide to the environment, posing long-term potential impacts on components of the environment, such as water quality.

Thus, the factors that need to be reviewed in assessing the effects of cyanide in the tailings solution are -

- the form of cyanide;
- the potential for metallo-complexation;
- disposal surface area, and the degree of exposure to sunlight and aeration which greatly enhance degradation;
- long-term levels of cyanide.

The cyanide will be in a reactive form and therefore available for degradation and complexation. The anticipated levels of metals in the tailings will be low. This is based on the facts that metal toxicities to plant life are not a feature of the Goldfields overburden and tailings, and that Lamont (1976), in an investigation of the tailings dumps south-east of Boulder, found metal levels to be generally below the detection limits of a spectrophotometer (<0.05 mg/mL Fe^{2+} and <0.005 mg/mL Zn^{2+}). With respect to cyanide, Lamont was unable to record any trace of cyanide in more than 60% of the dumps, despite cyanide treatment of 95% of the ore from which the tailings are derived. Consequently, the potential for metallo-cyanide complexation is considered to be low.

The tailings disposal method, involving the deposition of thin layers of wet tailings via a system of perimeter spigots over a large inwards draining area, maximizes the potential for cyanide degradation, as the potential for exposure to sunlight and atmosphere is maximized.

Tests have been conducted on behalf of Anglo American Pacific Ltd to quantify cyanide degradation. A prepared sample measuring 0.11% free cyanide (as NaCN), in a makeup tailings solution representative of the operational situation, was subjected to simulated decay trials. After four days of exposure to sunlight and the atmosphere, the measured level of free cyanide was less than 0.003% (as NaCN). The initial NaCN level was substantially higher than initial levels to be expected in practice, however the trial indicates the rapid rate of decay which can be expected to occur. The final CN^- levels in the storage and in any seepage which may occur are expected to be well below 0.0001% (1 mg/L CN^-).

5.5 Hazardous Materials

All hazardous materials will be stored in a fully enclosed storage compound which will be designed to satisfy all relevant regulations set by the Occupational Health, Safety and Welfare Department of Western Australia.

The release of HCN gas from the process has been taken into account in the plant design. Tanks will be well vented to the atmosphere in accordance with practices used successfully throughout the Goldfields.

5.6 Dust

Dust generation will not be a significant impact of the project. The mining operation involves the reclamation by water jets and collection of the mined tailings as a slurry for piping to the treatment plant. Consequently, dust generation will not be a feature of the mining operation, except possibly for short periods when conventional earthmoving equipment will be used for final cleanup at the end of each dump.

The final tailings disposal after retreatment will not generate large quantities of dust because the tailings are deposited wet, around the perimeter of the storage, spreading across the previously deposited layer of tailings towards the central decant systems. The upper layer of the tailings will be continually covered by new deposition, and the storage will remain wet throughout its operating life.

Some dust generation during the clearing, stripping and tailings storage construction phases is inevitable. However, this period is very brief and stripping operations will be avoided during periods of excessively high winds to minimize dust generation.

The duration of potential dust generation from the tailings storage batters will be minimized under the progressive rehabilitation strategy outlined in Section 5.9.4, whereby waste rock and topsoil are to be spread over tailings and revegetated progressively as the embankments are raised. The proposed location of the tailings storage, within a timbered region, which offers significant protection from high velocity surface winds, will also assist with minimizing dust generation.

The rehabilitation proposals for final decommissioning of the new storage will ensure that the site is a potential minor source of ongoing dust in the future, because of the following features -

- low slope angles on the embankments
- vegetation cover on the embankments
- stabilization cover and eventually vegetation, on top of the tailings storage
- surrounding protective zone of trees.

With respect to the relatively minor levels of dust expected to be generated by the project, it is significant that the project proposes to relieve the Goldfields district of a significant contributor to its dust problem, namely 272 ha, or about four-fifths of the exposed area of the tailings dumps to the south-east of the Boulder township. These tailings dumps were identified by Richmond et al (1973) as being the major source of dust pollution in the district.

5.7 Transportational and Supply Impacts

The mining operation will not involve trucking movements as the tailings will be recovered and slurried to the treatment plant by pipeline. The impact of operational and maintenance vehicles along the pipeline is not considered significant.

During the construction of the pipelines and any associated road and track crossings, formal detours will be provided where construction interferes with traffic. All construction will comply with the requirements of the Main Roads Department and Shire Authorities. Two crossings of Mt Monger Road will be required, one for the slurry pipeline and one for the water supply pipeline.

Construction of the power supply lines will be undertaken by the State Energy Commission of WA (SECWA), under standard SECWA safety procedures.

During rehabilitation phases, waste rock will be trucked to the tailings storage in road trains. The resultant increase in traffic along a portion of the Mt Monger road will occur for perhaps two months of the year.

At the completion of the tailings retreatment operation, smelter slag or similar appropriate stabilization material will be transported to the tailings storage site. Approximately 60 000 m^3 of material will be required to cover the top of the dump with a 40 mm layer of slag.

It is proposed to cover the mined surfaces with a 40 mm layer of slag or similar material. Approximately 200 000 m^3 of material will be required for this operation, spread over several years of progressive rehabilitation.

Operational transportational impacts are not considered to be significant as they involve the use of several conventional vehicles and 4WD utilities, and perhaps a bus for shift workers.

During the tailings embankment and plant construction phase, traffic movements will be increased above these levels. Road transport of some heavy machinery will occur, as will the transport of treatment plant components. The construction phase will therefore increase traffic on the Mt Monger Road and perhaps also on sections of other roads, but this period will be of relatively short and sporadic duration. Such movement is not uncommon in the Goldfields district.

The north-east and eastern sides of the tailings disposal area will be visible from the Trans Australian Railway, through a screen of sporadic trees. The evaluation of this aesthetic impact is subjective. The north-eastern corner of the tailings storage will present the lowest elevation above natural ground surface of approximately 8 m. The highest part of the embankment will be at the south-western corner, farthest from the railway line.

5.8 Noise

The use of hydraulic monitors will significantly reduce noise levels when compared to conventional earthmoving equipment.

With two (2) 150 mm monitors operating at the mining face, noise levels at a distance of 250 m are not normally greater than 65 db. At 60 m, the increase is only to 70 - 75 db. For comparison, most mining companies now require equipment (conventional earthmoving) to comply with the following peak levels -

Cabin noise (front end loader)	85 db
Spectator level at 7 m	90 db.

In some instances, suppliers of machinery have to make modifications to bring noise levels to regulation requirements. It is pointed out that, in the KALTAILS case, the monitors are operated by remote control, thereby eliminating the need for hearing protection.

5.9 Rehabilitation

5.9.1 Vegetation Clearing and Management

During the construction period, the disposal site will be cleared of vegetation in a chain and bulldozer operation. Salvageable timber (including sandalwood) will be recovered. The cleared vegetation will be windrowed or piled with a root rake blade and machine mulched. The mulch will be spread over the topsoil stockpile, providing a protective cover to wind and water erosion.

5.9.2 Topsoil Management

Topsoil will be stripped and temporarily stockpiled on a site specifically set aside for this purpose. Alternatively, to facilitate progressive reclamation of the topsoil for rehabilitation works during the project, several smaller stockpiles could be strategically located around the site, each mulched with vegetation and, if necessary, protected against dust and erosion.

Every attempt will be made to conduct soil stripping and handling operations to reduce dust levels, particularly when the wind direction is likely to carry dust towards the urban areas of Kalgoorlie-Boulder. Care will also be taken to prevent the destruction of soil structure.

Progressive rehabilitation will commence with the rehabilitation and revegetation of the primary embankment and the first and second lifts. As sufficient areas then become available for rehabilitation, the final cover will be drawn from the soil/mulch stockpile(s).

5.9.3 Rehabilitation Philosophy

The philosophy underlying the methods for rehabilitation described in this document has been developed from several principles, as follows -

- final landforms should be stable against the forces of wind and water erosion and be structurally sound
- final landforms should be non-toxic to surrounding fauna, flora and other downstream land users such as pastoralists
- aesthetically, final landforms should conform with the surrounding natural landforms (where the opportunity exists to achieve this)
- this project will alleviate the Goldfields district of a significant source of dust pollution
- the philosophy underlying the project's rehabilitation strategies will demonstrate new standards for responsible mine operation in the district
- the appointment of a project rehabilitation officer with funding for significant research and commitment to successful rehabilitation.

5.9.4 Rehabilitation Strategy for Tailings Disposal Area

The proposed rehabilitation strategy involves the progressive annual rehabilitation of the outer embankments following the guidelines presented in Table 13 and Figures 20 and 21.

As sufficient area of batter becomes available for final works (probably annually), the tailings will be flattened to slopes of around 1v:4h. A cover of waste rock/material, selected from a nearby mining operation for its chemical and physical suitability and its proximity to the site, will be spread at 1 m depth. Every attempt will be made to select a gap-graded material of low salinity and sodicity, containing sand and fine-sized particles dominated, by mass, by rock pieces up to cobble and boulder size. The waste material will be spread at 1:4 slope or shallower and will be covered by a layer of topsoil into which vegetation mulch and chips have been incorporated. The surface will be sown, probably aerially, in May with one or more cover crops on a trial basis.

Alternatively, and depending on the recommendations of local researchers, the introduced pasture phase may be omitted and salt-resistant species may be sown in May, in combination with 100 - 200 kg/ha phosphatic fertilizer (Table 14).

TABLE 13

GUIDELINES FOR REHABILITATION OF THE TAILINGS DISPOSAL AREA

Landform	Maximum Slope Angle	Maximum Length Without Soil Conservation Structures	Maximum Catchment	Timing of Works	Materials Cover	Vegetation Cover	Maintenance
Batters	1v:4h	30 m	1.5 ha	Annual, prior to May sowing	1. Flatten tails 2. Waste rock cover (0.5 - 1 m) 3. Topsoil/mulch cover	Secale cereale (cereal rye) followed by native species	NPK and P Fertilizer and earthworks as required
Top Surface	1v:150h Draining to central decant position	None	Entire top surface	Prior to decommissioning	Slag with waste rock windrows	Atriplex sp Maireana sp Eucalypts on windrows	As required

TABLE 14

LIKELY SUITABLE SPECIES FOR REVEGETATION

Atriplex bunburyana	(Saltbush)
Atriplex sp "pintharuka"	
Atriplex nummuleria	
Atriplex stipitata	
Atriplex semibaccata	
Maireana brevifolia	(Bluebush)
Maireana aphylla	
Eucalyptus sargentii	(Salt river mallet)
Eucalyptus camaldulensis	(River red gum)
Eucalyptus dundasii	(Dundas blackbutt)
Eucalyptus myradena	(Southern cross blackbutt)
Eucalyptus salubris	(Gimlet)
Eucalyptus occidentalis	(Flat-topped yate)
Tamarix articulata	(Athel tree)
Tamarix gallica	(French tamarisk)

The preparation of the final surface will take place progressively, with sections for revegetation completed by May so that sowing can take place in the cooler months when evaporation is lowest.

Following the progressive completion of 30 m of batter slope, a 5 m wide berm will be created which backslopes at 1% to a waterway at 0.5% slope. Runoff from the upper batter will collect in the waterways and be disposed of down the lower batter via suitable drop structures, such as fabric-lined, rock-filled waterways.

The rehabilitation strategy for the top surface of the tailings disposal area involves retaining the end-of-treatment slope of 1:150, which will drain to the central decant system used during operation. The surface will be ripped and covered with a thin layer (say 40 mm) of nickel slag or alternative suitable material to minimize dust and enhance leaching whilst retaining moisture by reducing evaporation. Covering the top surface with topsoil only is not feasible or viable because the saline tailings would soon contaminate the topsoil through the capillary rise of salts.

Following the application of a slag cover, the surface may be intersected by windrows of waste cover into which native tree and shrub species can be planted. By this time (approximately 14 years), sufficient information and suitable methods should be forthcoming from AAP and WA Government research to successfully colonize the slag-covered tailings with salt-tolerant native species.

In the event that revegetation is unsuccessful because of the very high salinity of the tailings and the available water, the top surface of the storage will be armoured with waste rock or other suitable material to control dust and erosion.

5.9.5 Mined Tailings Areas

The rehabilitation of the mined tailings areas will be progressive and involves preparing and stabilizing the surface prior to leaving the surface for at least two years while leaching of salts can take place.

It is intended that the surface will be cross-ripped following the re-establishment of surface drainage conditions, interrupted by the deposition of tailings dumps. The surface will be covered with a layer of nickel slag, or alternative and appropriate material, and left to open-leach. In this manner, dust abatement will be effective whilst leaching and the selection of suitable plant species takes place. However, these procedures will require the permission of the underlying tenement holders.

5.9.6 Plant Site

The plant site and associated areas of disturbance will be cleared of all buildups, plant and debris, and fully restored at the completion of the project.

5.9.7 Rehabilitation of Supply Lines

During the decommissioning operation, all aboveground installations and lines will be removed. This will be conducted with a minimum of disturbance to surrounding soils and vegetation. Below ground installations, such as the water supply line, will remain as it is uneconomic to reclaim, and removal would involve considerable additional disturbance to an area rehabilitated less than ten years previously (following installation).

Sumps associated with the water supply and slurry lines will be cleaned of residue and the sumps infilled with the material stockpiled adjacent to them during excavation.

Where necessary, restoration will be assisted by the addition of native seed and fertilizer.

CONTRIBUTORS TO PREPARATION OF NOTICE OF INTENT

The Notice of Intent has been compiled by Australian Groundwater Consultants Pty Limited, with contribution on specific aspects from -

ORGANIZATION	ACTIVITY
. Anglo American Pacific Ltd and . McDonald Resources Pty Ltd	Company information and engineering/operational aspects of the mining and processing operation.
. McArthur and Associates	Flora, fauna, soils and Aboriginal heritage.

In addition, discussions were held with officers of the following State and Commonwealth Government organizations -

- Agriculture Protection Board of Western Australia
- Commonwealth Department of Science and Technology
- Department of Agriculture
- Department of Conservation and Land Management
- Department of Mines
- Department of Resources Development
- Environmental Protection Authority
- State Energy Commission of Western Australia
- Water Authority of Western Australia.

REFERENCES

Anglo American American Corporation of South Africa Ltd (1982), "Kalgoorlie Tailings Project - Second Appraisal Study Conducted on Behalf of Australian Anglo American". 3 Vols.

Australian Groundwater Consultants Pty Ltd (1985a), "North Kalgurli Water Supply, Augmentation Studies, Stage 3". (Unpublished report prepared for North Kalgurli Mines Ltd.)

Australian Groundwater Consultants Pty Limited (1985b), "Kaltails Project, Water Supply Studies, Stage 2". (Unpublished report prepared for Australian Anglo American Ltd.)

Australian Groundwater Consultants Pty Limited (1987a), "Kalgoorlie Tailings Project, Notice of Intent". (Unpublished report prepared for Anglo American Pacific Ltd.)

Australian Groundwater Consultants Pty Limited (1987b), "Kaltails Project, Condemnation Drilling M 26/82". (Unpublished report prepared for Anglo American Pacific Ltd.)

Australian Groundwater Consultants Pty Limited (1987c), "Kaltails Project, Water Supply Investigation". (Unpublished report prepared for Anglo American Pacific Ltd.)

Beard, J S (1978), "The Vegetation of the Kalgoorlie Area, Western Australia - Map and Explanatory Memoir, 1:250 000 Series". 2nd Edition. Vegmap Publications.

Beard, J S and Sprenger, B S (1984), "Geographical Data from the Vegetation Survey of Western Australia". Vegmap Publications.

Bureau of Meteorology, Department of Science (1987), "Estimation of Probable Maximum Precipitation for a Tailings Dam at Lakewood (Boulder), WA".

Burnside, D (1987), "Soil and Management". Paper presented to the Workshop on Environmental Management in the Goldfields, Kalgoorlie, May 1987, WA Chamber of Mines.

Caldwell, J A, and Robertson, A McG (1983), "Selection of Tailings Impoundment Sites". Die Siviele Ingenieur in Suid-Afrika - Oktober 1983.

Department of Mines (1988), "The Golden Mile Environmental Strategy".

Environmental Protection Authority (1975), "Conservation Reserves for Western Australia, Systems 4, 8, 9, 10, 11, 12".

Flavell, D J (1984), "Design Flood Estimation in Western Australia". A paper presented to the NAASRA-BEC Seminar - Waterway Analysis and Design (Main Roads Department, WA).

Goldfields Dust Abatement Committee (1984), Reducing the Dust Nuisance. GDAC Publication.

The Institution of Engineers, Australia, 1977. Australian Rainfall and Runoff - Flood Analysis and Design.

Lamont, B (1976), "The Soils and Plants of the Eastern Goldfields With Particular Reference to the Capacity of the Tailings Dams to Support Vegetation". WAIT-AID LTD, Publication No 7404059.

McArthur and Associates (1987), "Biological Surveys of the Kalgoorlie Tailings Project Area".

Money Mining NL (1986), "Prospectus" issued April 1986.

Northcote, K H, Isbell, R E, Webb, A H, Murtha, G G, Churchwood, H M and Bettaney, E (1968). Atlas of Australian Soils, Sheet 10, CSIRO.

Nunn, R M (ed) (1981), "Dust Abatement in the Goldfields of Western Australia - Progress Report for 1973-1981 and Situation Review of the Goldfields Dust Abatement Committee", by the Dust Abatement Technical Sub-Committee. DCE Bulletin No 86.

Petersen, A (1987), "Waste Management and Stabilization". A paper presented to the Workshop on Environmental Management in the Goldfields, Kalgoorlie, May 1987. WA Chamber of Mines.

Richmond, P, Hacker, R and Verschuer, J (1973), "Report on the Dust Problem in the Kalgoorlie-Boulder Region". DCE.

Ryan, P (1987), "An Assessment of a Mine Site Rehabilitation Project in a Seasonal Tropic Environment". Unpublished Master of Science Thesis, Macquarie University.

Vick, S G (1983), "Planning Design and Analysis of Tailings Dams", Wiley & Sons, USA.

Western Mining Corporation Ltd (1978), "Environmental Review and Management Programme for Proposed Metallurgical Research Plant at Kalgoorlie, Initially for Yeelirrie Uranium Ore".

Williams, I R (1970), "Kurnalpi 1:250 000 Geological Series Map Sheet and Explanatory Notes", GSWA.

Work Party on Conservation and Rehabilitation in the Mining Industry (1985), "Report on Conservation and Rehabilitation in the Gold Industry to Hon Minister for Minerals and Energy".

APPENDIX A

CONDITIONS APPLYING TO
MINING LEASE M 26/82

LEASE NUMBER 26 82 SCHEDULE OF CONDITIONS:

1. Survey.

2. Compliance with the provisions of the Aboriginal Heritage Act, 1972 to ensure that no action is taken which is likely to interfere with or damage any Aboriginal site.

3. Compliance with the provisions of the Forests Act and Regulations, and the Bush Fires Act and Regulations.

4. No developmental or productive mining being commenced without advising the Officer in Charge, Forests Department, Kalgoorlie, of the details concerning the proposed operations.

5. No open cut mining being permitted without the approval of the Forest Officer at Kalgoorlie and compliance with such further conditions as the Conservator of Forests may consider necessary.

6. The lessee paying in advance to the Conservator of Forests compensation for areas to be cleared in the process of or associated with mining operations. The amount of compensation payable being determined by agreement between the lessee and the Conservator of Forests having regard to the current rate of compensation paid for areas cleared for bauxite mining in the Darling Range.

7. The lessee informing the Officer in Charge, Forests Department, Kalgoorlie, from time to time of the whereabouts of the operation on the lease area (unless otherwise advised by the Officer in Charge, or his nominee).

8. Then lessee taking all reasonable precautions not to unnecessarily destroy or damage any tree or woody shrub on the area.

9. The lessee keeping the area free from litter and rubbish and upon the completion of operations, leaving the site in a clean tidy condition.

10. The lessee refraining from allowing any firearms to be taken onto, or used on the lease area.

11. The lessee refraining from establishing any camp, base works or area, fuelling depot, or similar establishment on the lease area unless the site and access has been approved beforehand by the Officer in Charge, Forests Department, Kalgoorlie.

12. During and upon completion of mining operations, the lessee taking such measures as are reasonable and practicable for the rehabilitation of the area.

APPENDIX B

LETTER TO
THE DEPARTMENT OF ABORIGINAL SITES,
WESTERN AUSTRALIAN MUSEUM

McARTHUR & ASSOCIATES
Environmental, Landuse & Forestry Consultants

PO Box 522
South Perth 6151
WESTERN AUSTRALIA

(09) 474 1906

The Registrar,
Department of Aboriginal Sites,
17 Emerald Street,
West Perth, W.A., 6005.

8th June,1987

ABORIGINAL SITES - HANNANS LAKE AREA - KALGOORLIE

As part of a Notice of Intent (NoI) for a mine tailings reworking project on behalf of Australian Anglo Pacific Limited, we are carrying out a series of surveys over an area south-east of Kalgoorlie and north of Hannanans Lake (see area defined on map).

We have previously lodged a Search for Sites in the area (dated 2/6/87) and were informed that no Aboriginal Sites were registered over the area.

We will carry out a preliminary inspection for sites in association with our biological survey, and the NoI will include a statement concerning traditional aboriginal activities in the area. We will be recommending to our client that all provisions of the Aboriginal Heritage Act are complied with and accordingly, a systematic survey for traditional Aboriginal activity should be carried out before any earthworks commence in the area.

We seek a statement from your Department indicating acceptance of the above conditions as being satisfactory for inclusion in a Notice of Intent.

Please treat the above information with confidence, and if further detail is required contact this office.

Yours sincerely,

G.M.McARTHUR

Managing Partner.

APPENDIX C

LETTER FROM

WESTERN AUSTRALIAN MUSEUM

Western Australian museum

Francis Street Perth
Western Australia 6000
Telephone (09) 328 4411

Date: 9 June 1987

Your Ref:

Our Ref: 225/77

Managing Director,
McArthur & Associates,
P.O. Box 522,
SOUTH PERTH 6151

ABORIGINAL SITES - HANNANS LAKE AREA - KALGOORLIE

I refer to your letter of 8 June.

We are satisfied with the conditions indicated in your letter to be included in a Notice of Intent.

V. Novak

V. NOVAK,
Assistant to Registrar,
DEPARTMENT OF ABORIGINAL SITES.

APPENDIX D

LETTER FROM

R H PEARCE

ON ABORIGINAL USAGE OF LAND

McArthur & Associates,
P.O. Box 522,
South Perth, 6151.

R.H.PEARCE
21 Davies Crescent
Kalamunda, 6076.

Attention : Mr. G. McArthur.

9th June, 1987

ABORIGINAL USAGE OF LAND - KALGOORLIE REGION

No traditional nor archaeological sites are registered at the Department of Aboriginal Sites for the land concerned in this report.

It is recommended the developers consult relevant local aboriginal communities to determine if anyone has any knowledge of traditional usage in the area. There will be also an inspection of the land by a registered consultant to identify any surface indications of prehistoric sites.

This part of the country, like most of inland Australia, was very sparsely populated before European colonization, and the aboriginal groups were nomadic, obliged to move frequently from one locality to another, according to the availability of naturally occurring food sources and especially water. Rainfall is light and unpredictable and the only reliable water available to a hunting people is in widely scattered pools, rock holes and soaks. Creeks seldom flow and most 'lakes' are salty.

The pattern of aboriginal living in such conditions is well documented by R.A.Gould in publications such as Yiwarra (1969, Collins), Living Archaeology, the Ngatatjara of Western Australia (1969, Southwestern Journal of Archaeology), Uses and Effects of Fire Among the Western Desert Aborigines (1971, Mankind vol 8).

The primary concern particularly during the hot dry summer was to camp near one of a number of water sources known by experience within the range of each tribal area. The smallest sources were used up first and the largest kept for later.

The size of the population was limited to the numbers that could survive through the worst conditions such as sustained drought. Conditions and customs were often harsh (D. Bates, 1938, The Passing of the Aborigines) and there is little evidence of organized attempts to ease the situation, such as by protective clothing, buildings, or long-term storage of food and water.

The pre-eminence of water supplies in nomadic living meant that such localities were commonly regarded as important by traditional oriented people, not only for mundane or secular activities but also for sacred and secret associations through myths, ceremonies, lineage etc. Social gatherings had to be held within walking distance of a water source, thus specific sites of significance are usually located nearby. Even lineage and locality links could be fostered by arranging a birth to occur at a selected place.

R.H.P.

Aspects of desert languages and myths are discussed by W. Douglas (1979, in Aborigines of the West, eds R.M & C.H Bernott, UWA) and by Bates (1938). Most of the traditional living patterns have now gone from the region but some practices remain in more remote areas in the east of the State, such as Warburton and Cundeelee.

Since the Kalgoorlie district had few surface water holes it was unlikely to be frequented by traditional travellers, and in particular the porous soils of the presently proposed development area suggest that this area would not be a camping site, although it could have been traversed and exploited by hunters seeking plant and animal foods.

The above information can be incorporated into the Notice of Intent, however a more representative statement of the area status can be determined by appropriate survey.

Yours sincerely,

R.H. Pearce

R.H.PEARCE B.Sc.,M.A.,M.A.A.C.A.

PLATE I : TAILINGS DUMPS IN THE LAKEWOOD AREA , BOULDER

PLATE 2

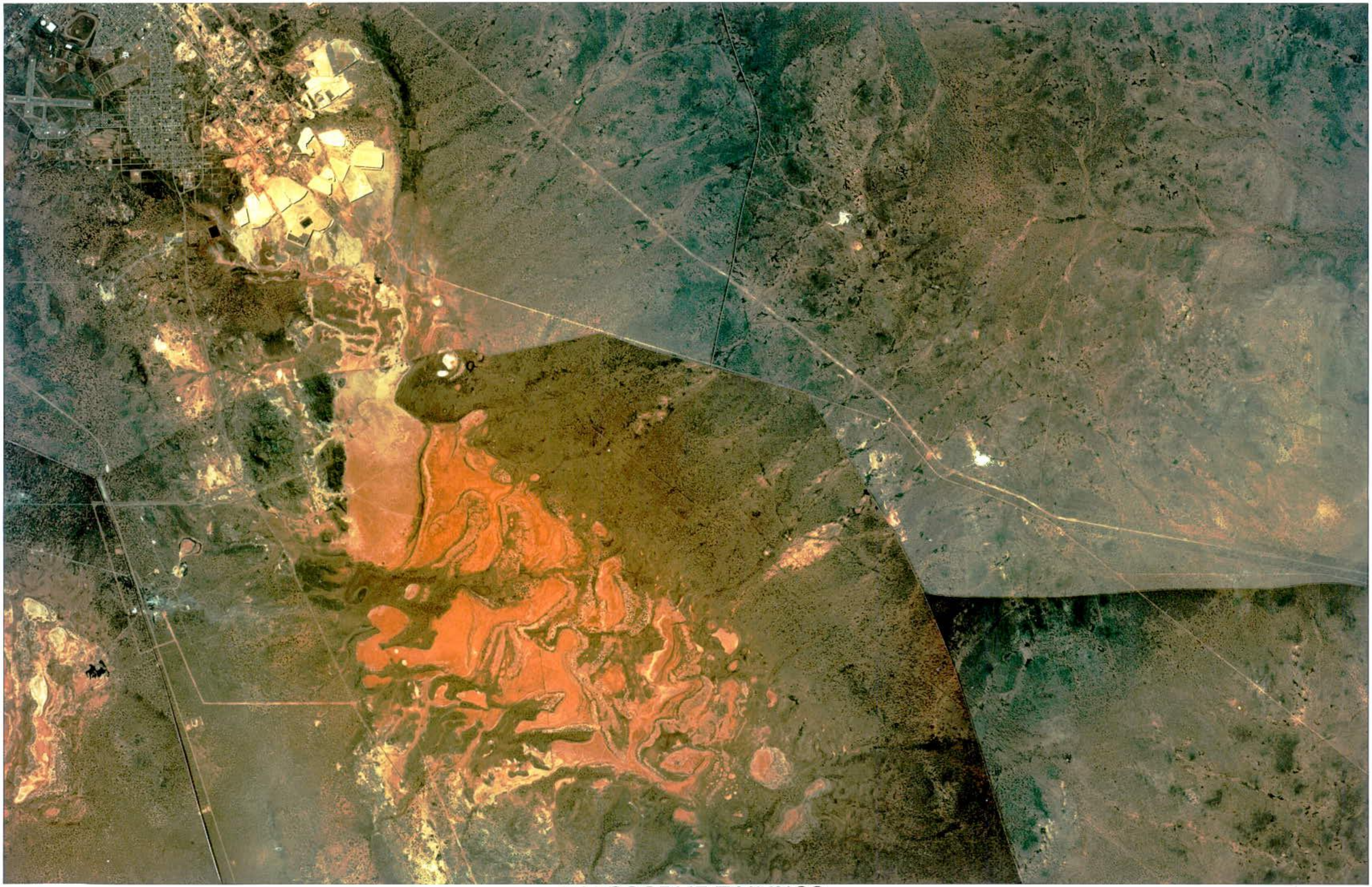
PHOTOGRAPH AT 1:100 000 APPROXIMATE SCALE
WITH OVERLAYS

OVERLAY A: LAND USE MAP

OVERLAY B: TENEMENTS RELATING TO THE PROJECT

OVERLAY C: DRAINAGE SYSTEM

OVERLAY D: PROJECT LAYOUT



Prepared For
ANGLO AMERICAN PACIFIC LIMITED

KALGOORLIE TAILINGS
RETREATMENT PROJECT

Date of photography: September 1984
Scale of photography: 1:100 000 approx.

PLATE 3

PHOTOGRAPH AT 1:25 000 APPROXIMATE SCALE
WITH OVERLAYS

OVERLAY E: LAND USE MAP
OVERLAY F: TENEMENTS RELATING TO THE PROJECT
OVERLAY G: PROJECT LAYOUT

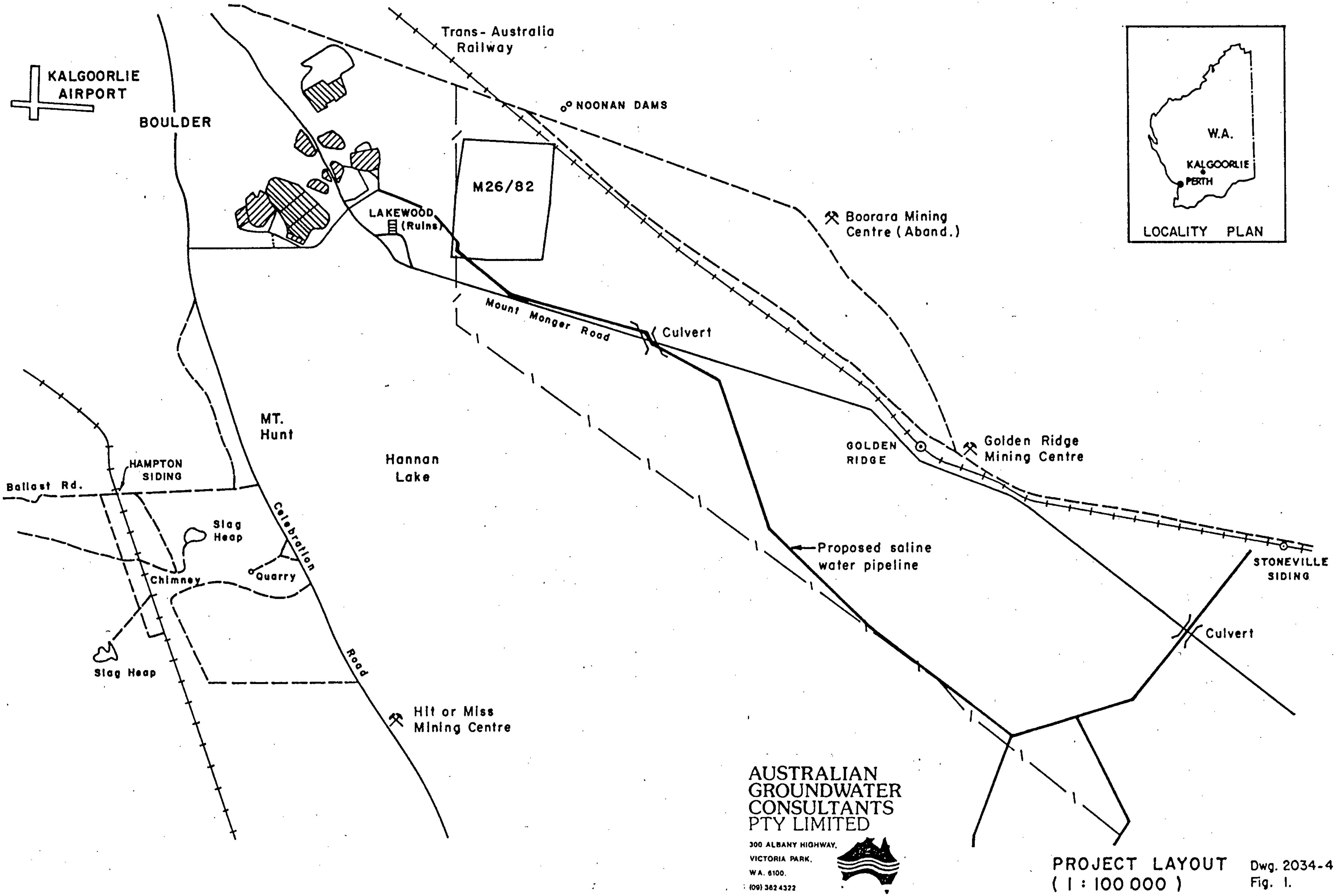
Prepared For
ANGLO AMERICAN PACIFIC LIMITED

KALGOORLIE TAILINGS
RETREATMENT PROJECT

Date of photography: March 1985
Scale of photography: 1:25000 approx.

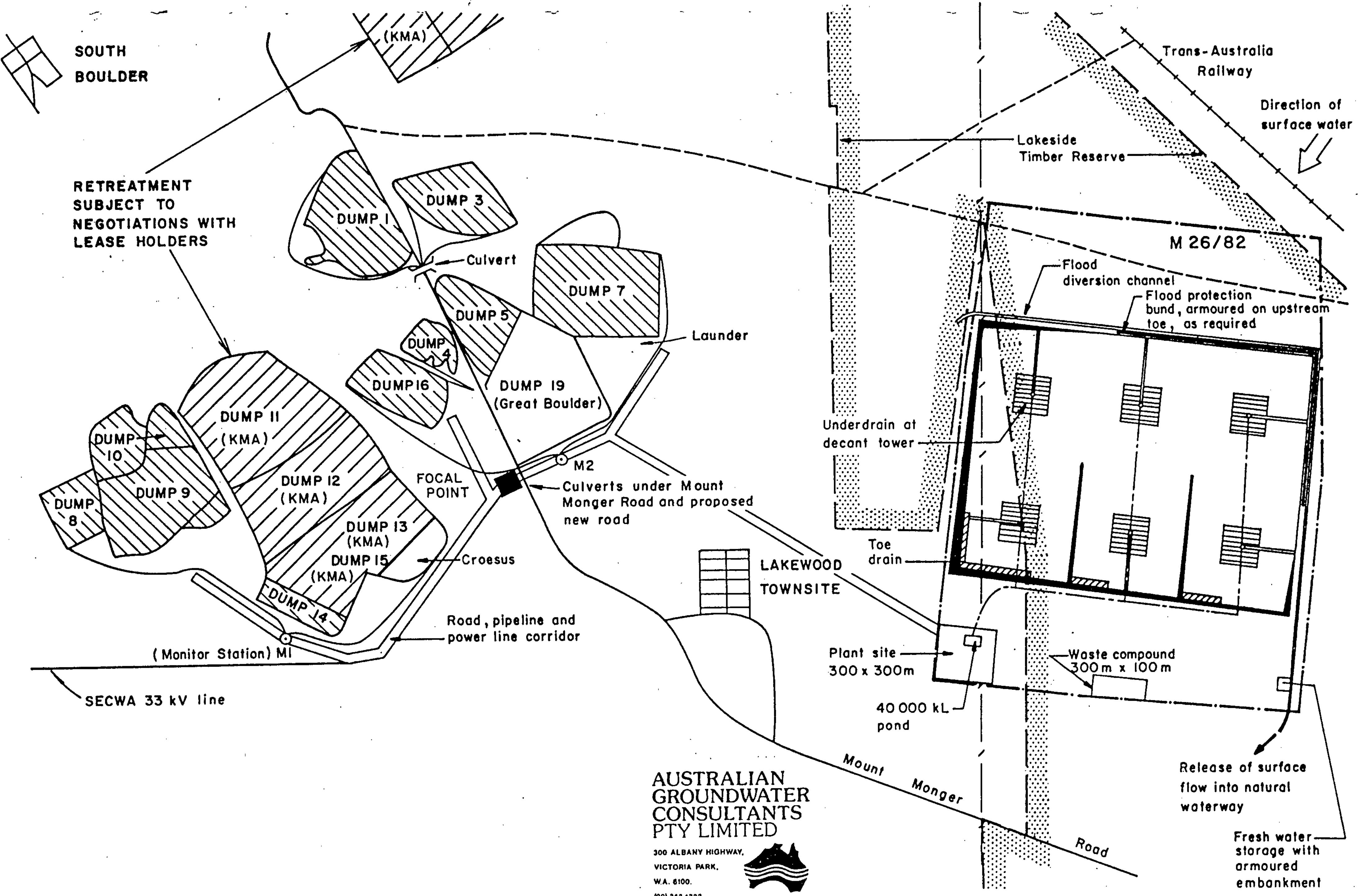
PLATE 4 : TYPICAL WOODLAND VEGETATION

PLATE 5 : TYPICAL LOW SHRUB VEGETATION



PROJECT LAYOUT
(1 : 100 000)

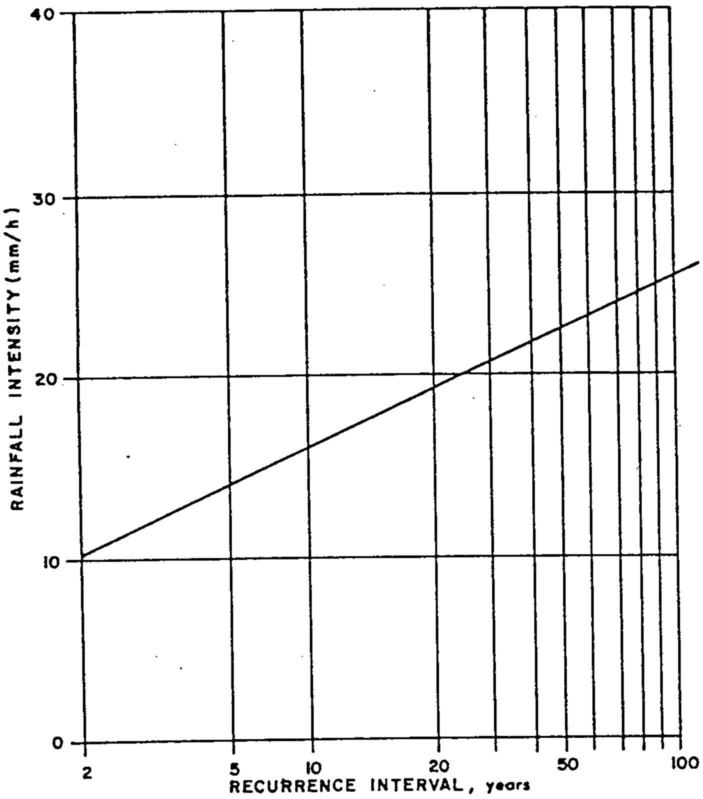
Dwg. 2034-4
Fig. 1.



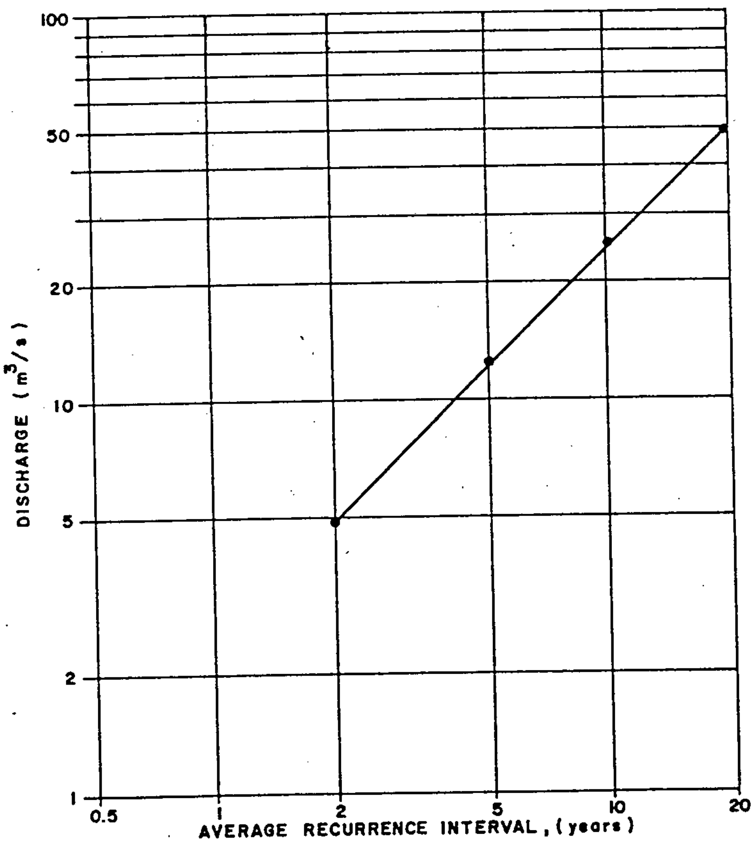
AUSTRALIAN
GROUNDWATER
CONSULTANTS
PTY LIMITED

300 ALBANY HIGHWAY,
VICTORIA PARK,
W.A. 6100.
(09) 362 4322.

PROJECT LAYOUT (1 : 25 000)
Dwg. 2034-5
Fig. 2

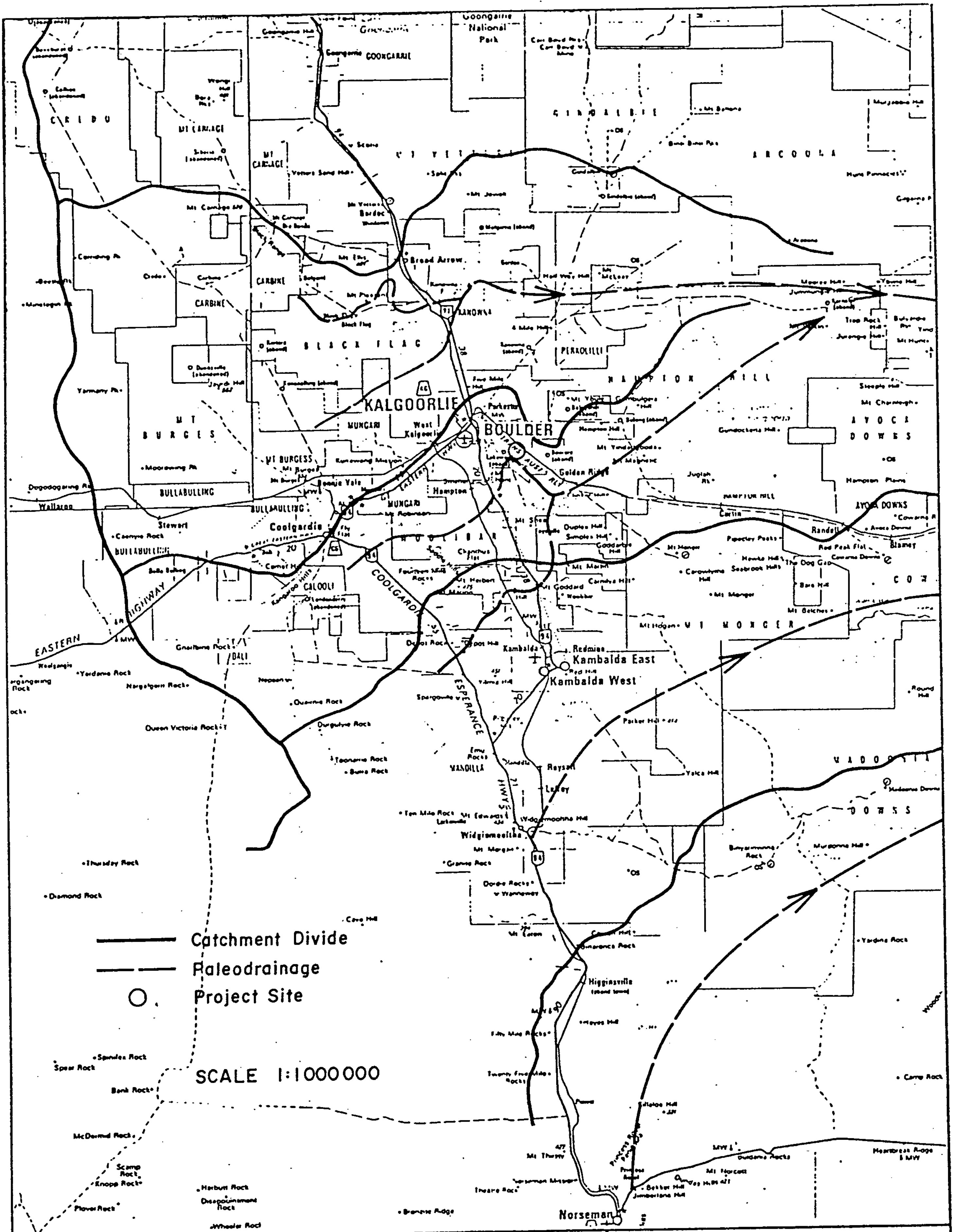


Rainfall Intensity- Frequency curve for a duration of 1.8 hours at Kalgoorlie (Australian Rainfall and Runoff)



Estimated peak discharges into tailings disposal area based on MRD Rational Method

REVISIONS				AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED	HYDROLOGY OF TAILINGS DISPOSAL AREA
Rev.	DESCRIPTION	Drawn Date	Chk'd Date		Date June, '87 · Dwg. 2034-6 · Fig. 3

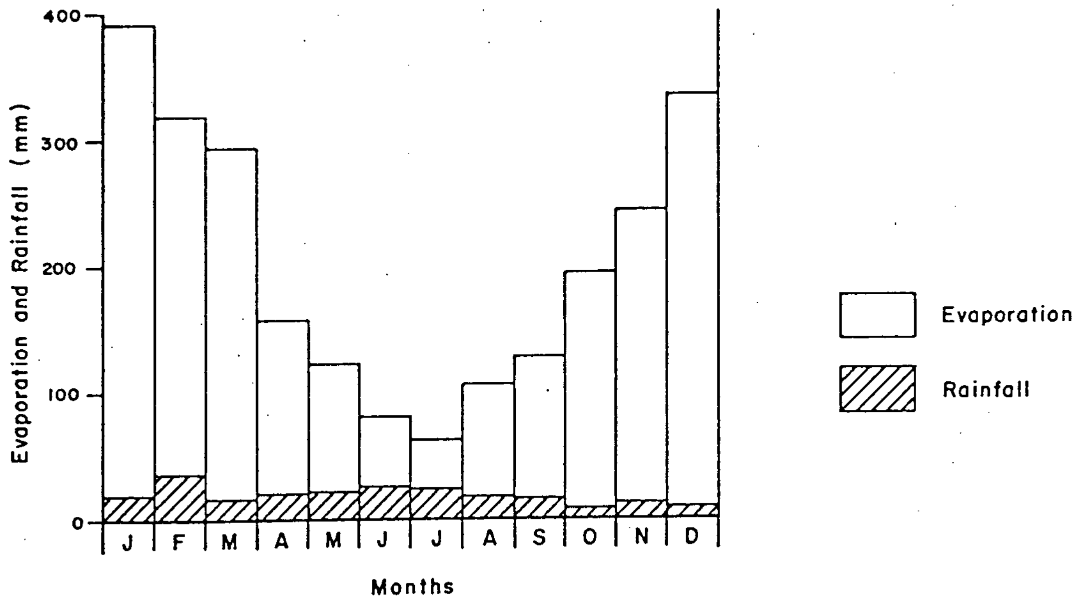


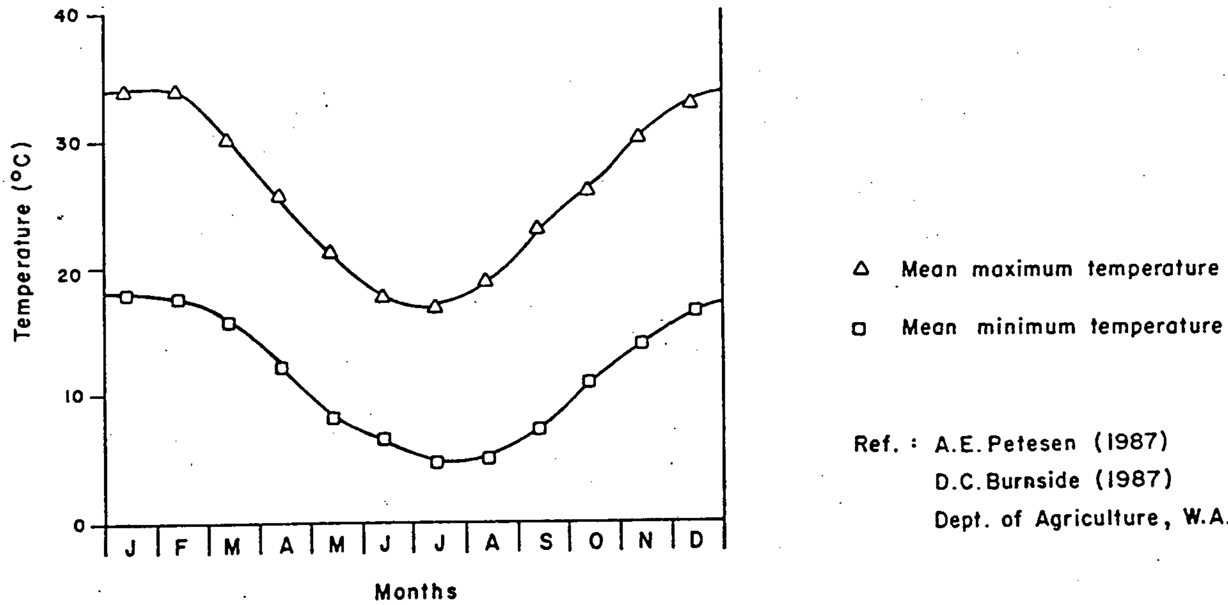
REVISIONS				
	Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

REGIONAL GROUNDWATER RESOURCES

Date June, '87 | Dwg. 2034-7 | Fig. 4





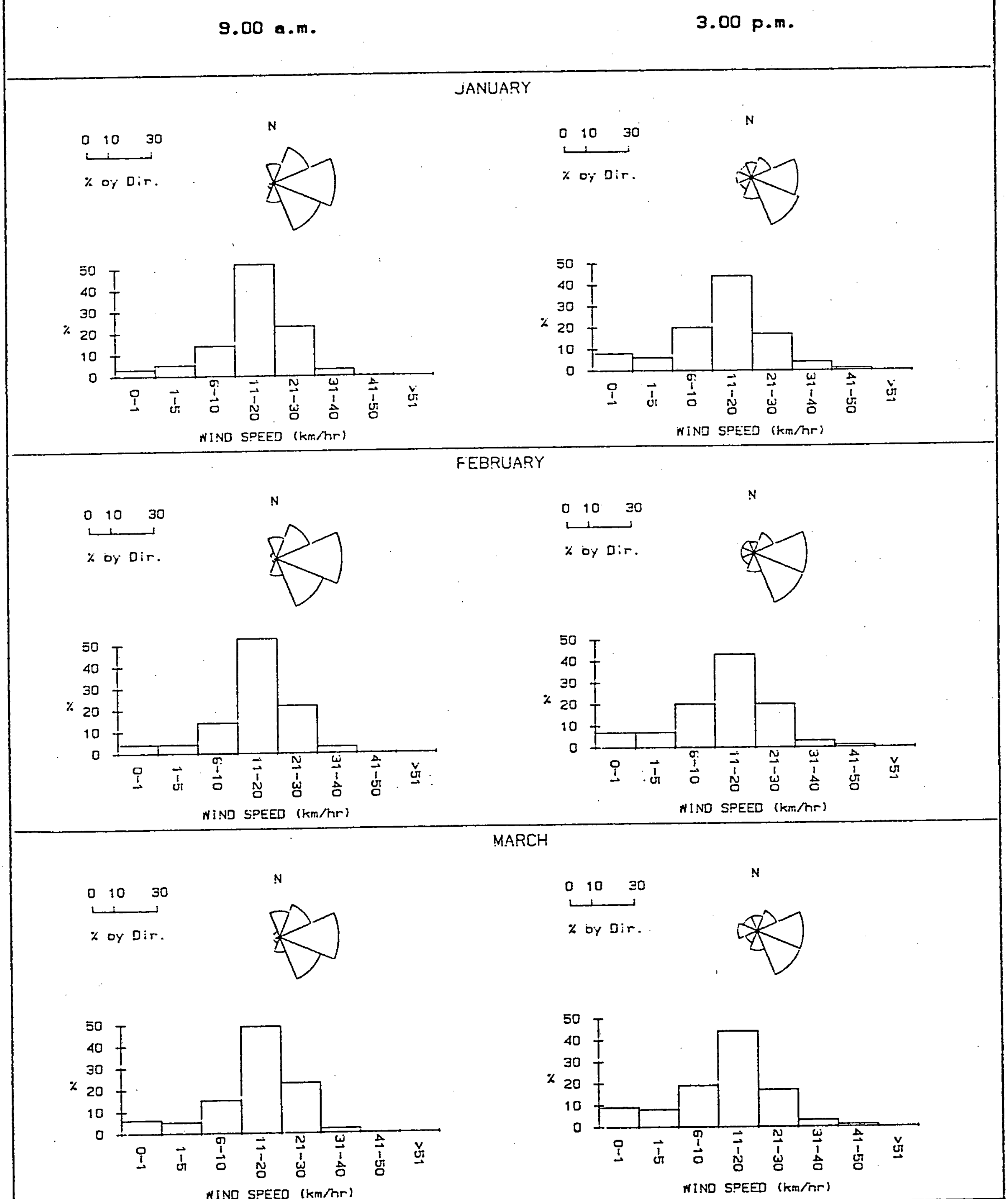
Ref. : A.E. Petesen (1987)
D.C. Burnside (1987)
Dept. of Agriculture, W.A.

REVISIONS			
Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

CLIMATIC DATA FOR KALGOORLIE

Date June, '87 | Dwg. 2034 - 8 | Fig. 5



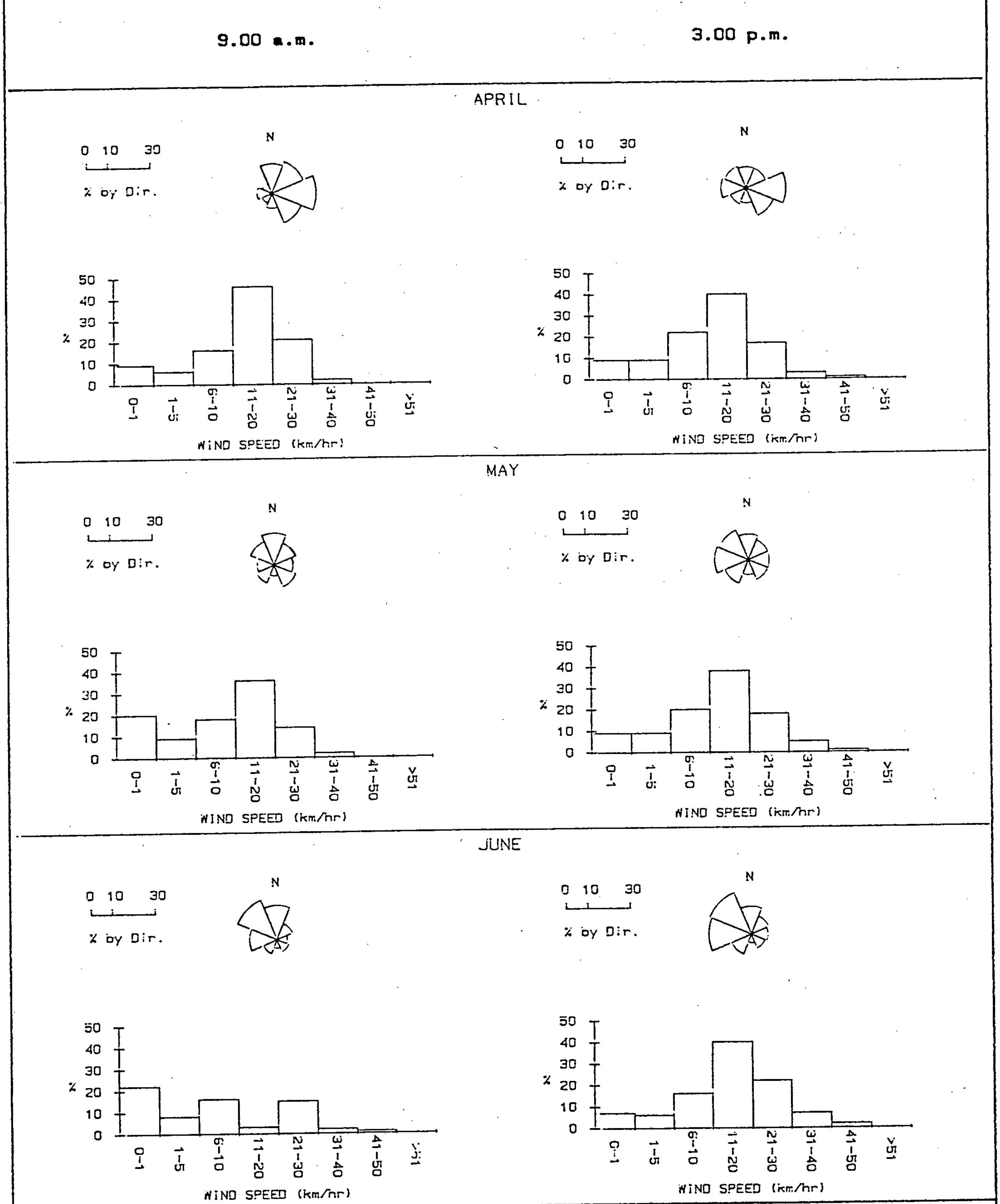
REVISIONS

Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN
GROUNDWATER
CONSULTANTS
PTY. LIMITED

WIND DATA for JAN.-MARCH.

Date:	Dwg:	Fig:
MAY 87	2034- 9	6

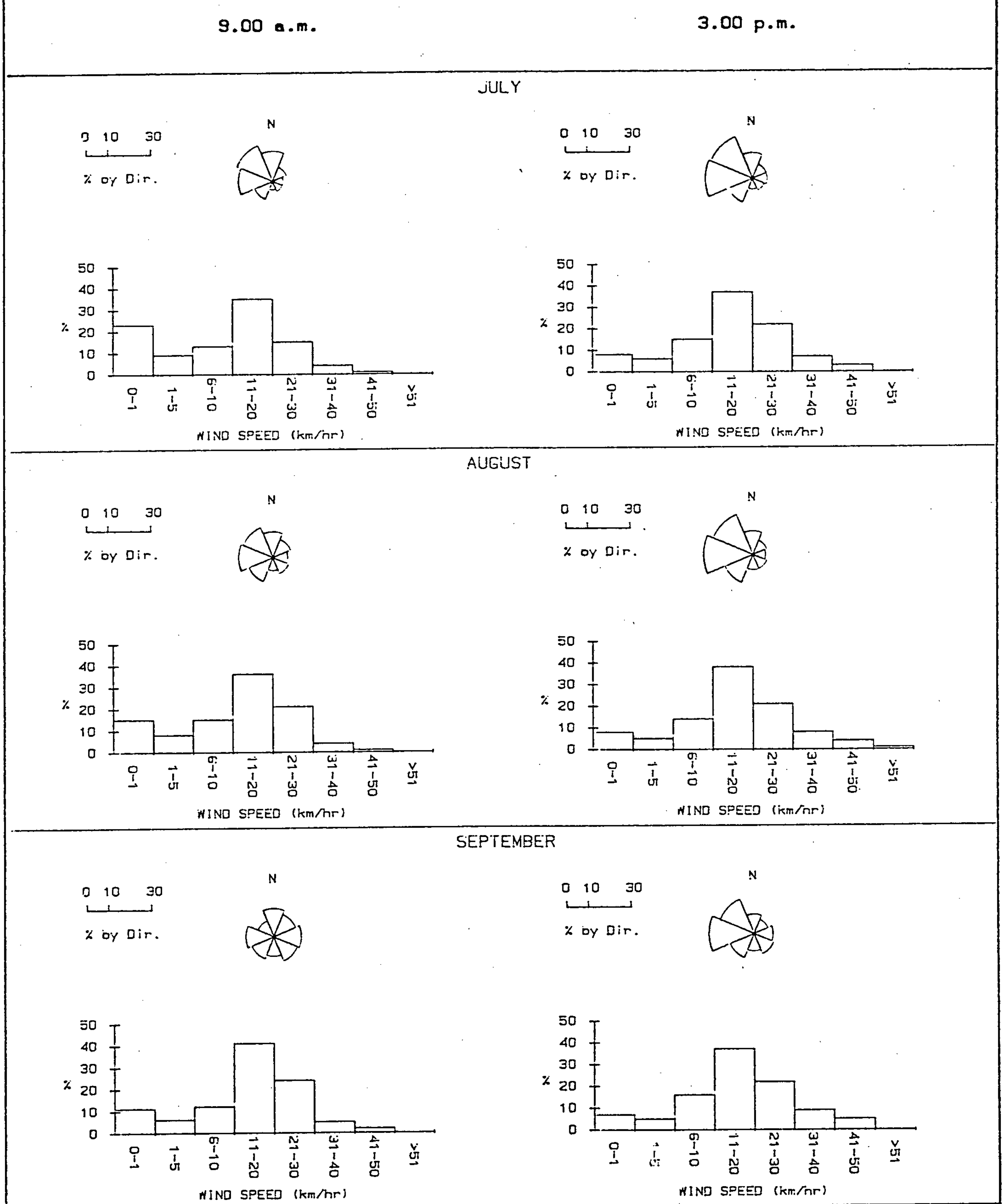


REVISIONS			
Rev.	DESCRIPTION	Drawn Date	Chk'd Do-u

AUSTRALIAN
GROUNDWATER
CONSULTANTS
PTY. LIMITED

WIND DATA for APRIL-JUNE.

Date:	Dwg:	Fig:
MAY 87	2034-10	7



REVISIONS				
Rev.	DESCRIPTION	Drawn Date	Chk'd Date	

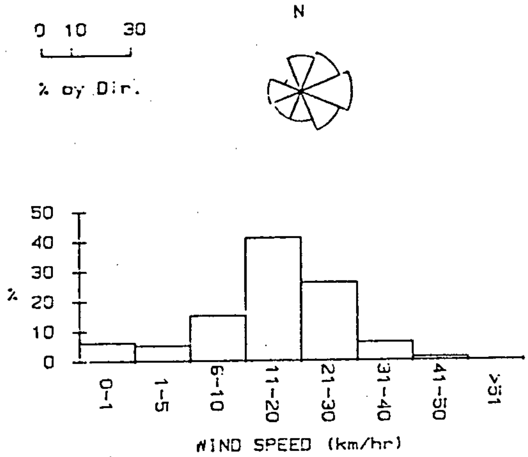
AUSTRALIAN
GROUNDWATER
CONSULTANTS
PTY. LIMITED

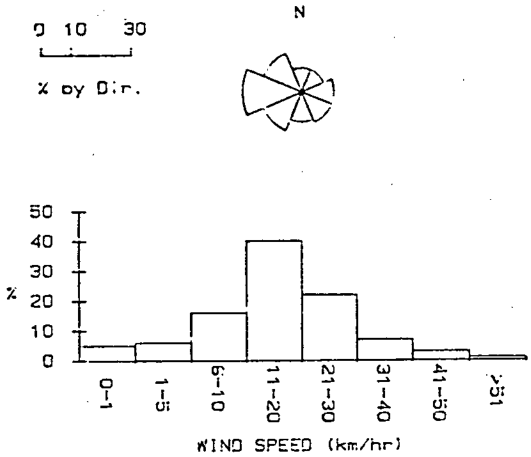
WIND DATA for JULY - SEPT.

Date:	Dwg:	Fig:
MAY 87	2034-11	8

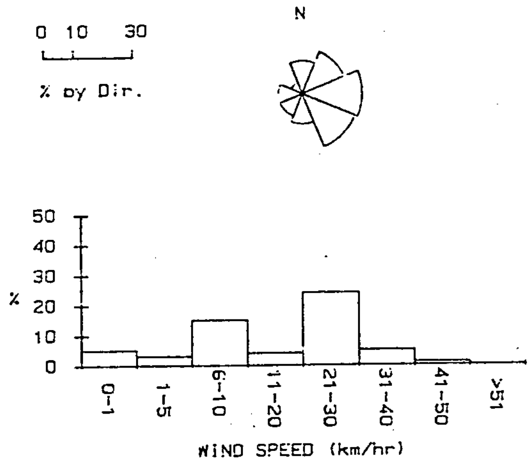
9.00 a.m.	3.00 p.m.

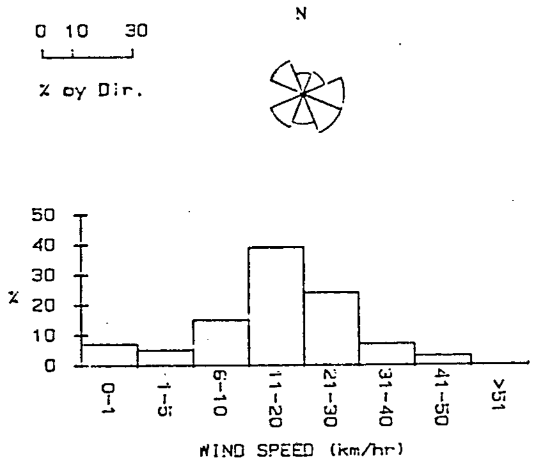
OCTOBER



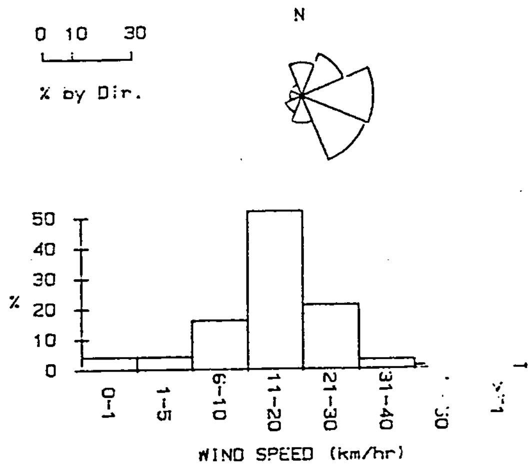


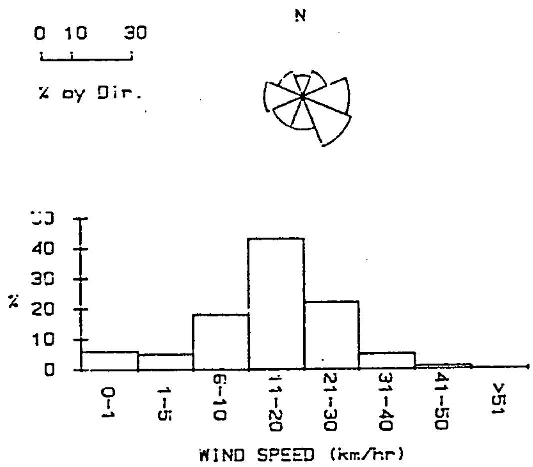
NOVEMBER





DECEMBER



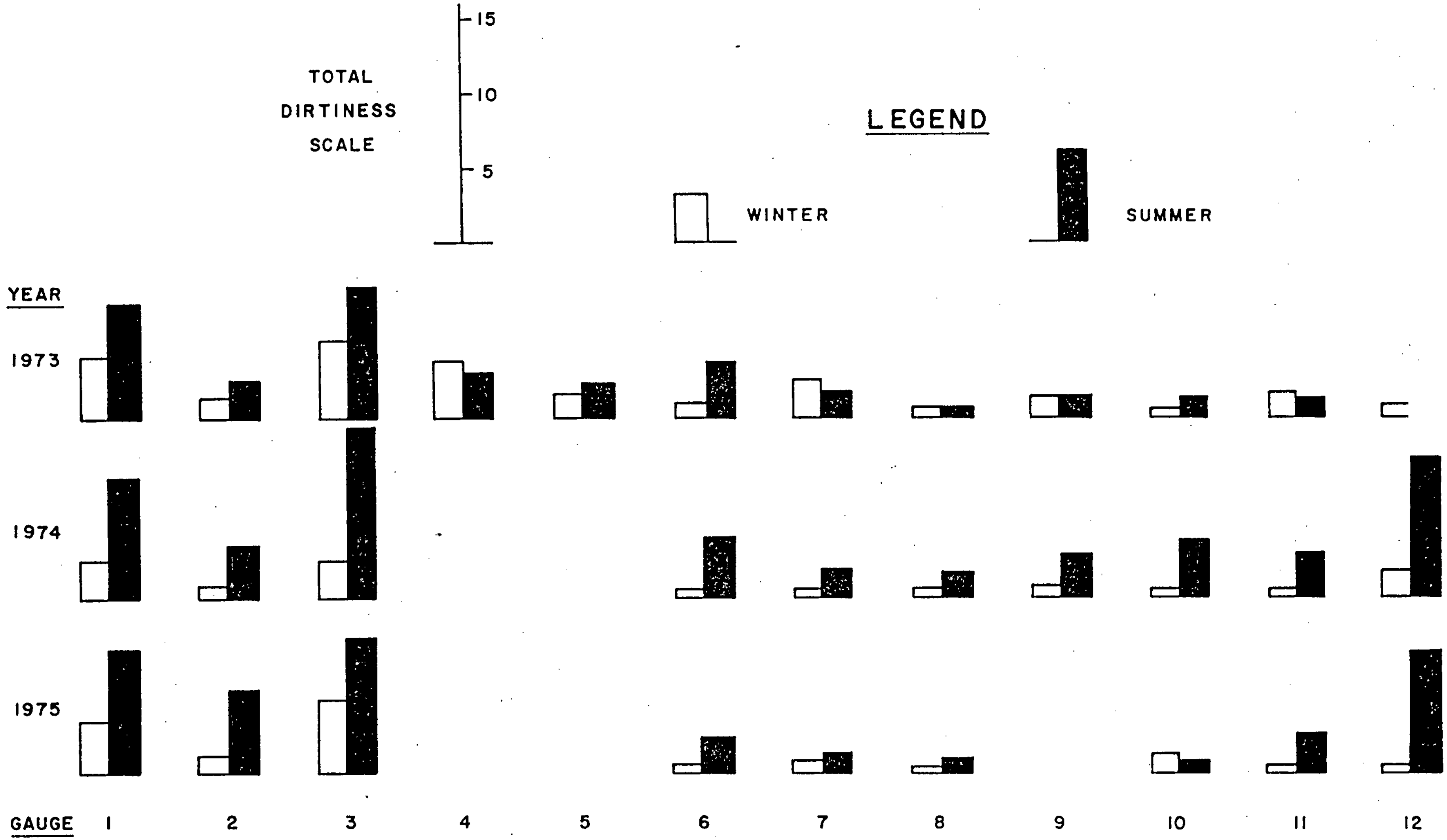


REVISIONS			
Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN
GROUNDWATER
CONSULTANTS
PTY. LIMITED

WIND DATA for OCT.– DEC.

Date:	Dwg:	Fig:
MAY 87	2034–12	9



1. From, Nunn (Ed), 1981

REVISIONS

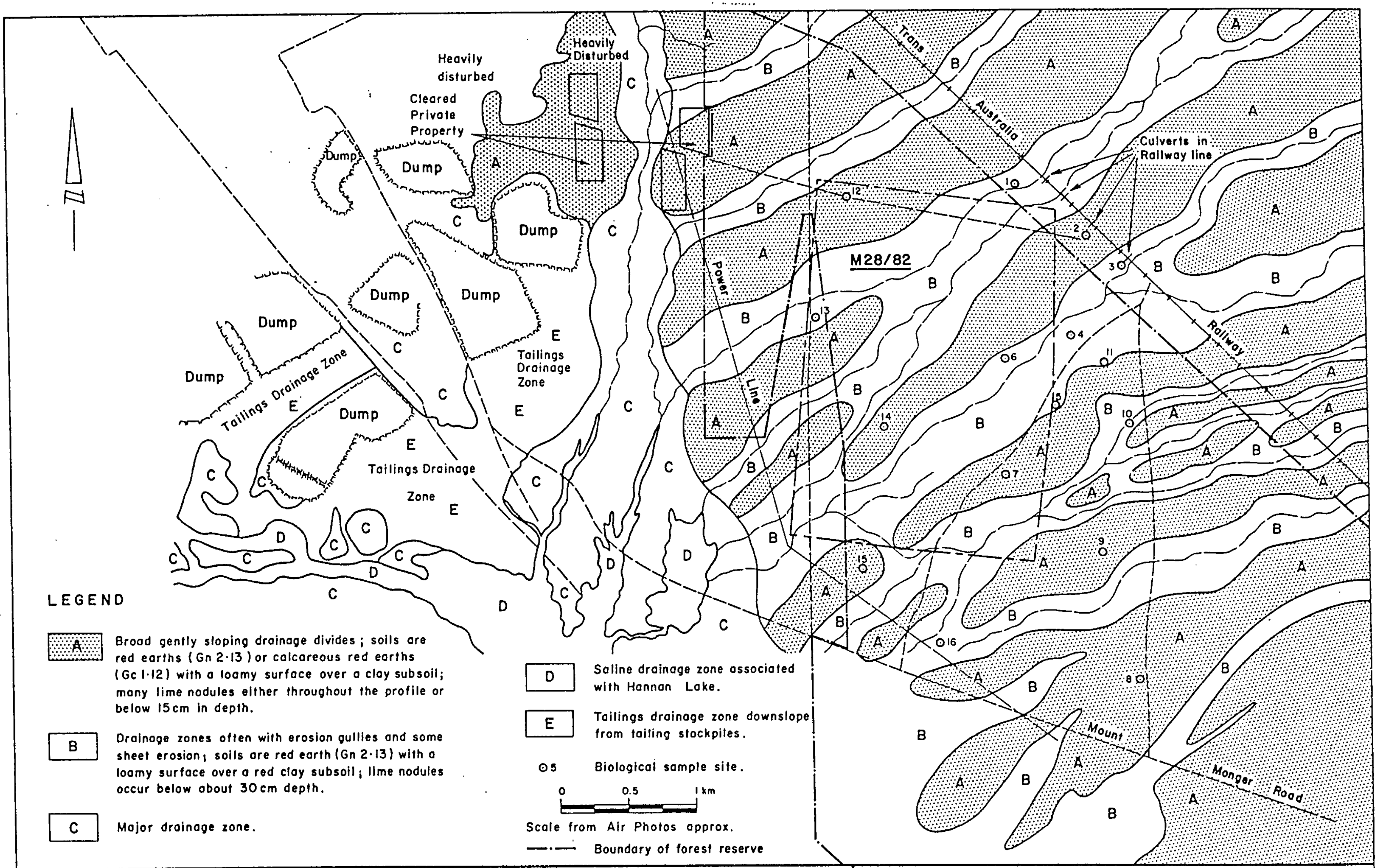
Rev.				
DESCRIPTION				
Drawn Date				
Chk'd Date				

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

COMPARISON OF AVERAGE SUMMER AND WINTER DUST LEVELS

Date June, '87 | Dwg. 2034-13 | Fig. 10

[redacted]



LEGEND

A — Broad gently sloping drainage divides; soils are red earths (Gn 2·13) or calcareous red earths (Gc 1·12) with a loamy surface over a clay subsoil; many lime nodules either throughout the profile or below 15cm in depth.

B — Drainage zones often with erosion gullies and some sheet erosion; soils are red earth (Gn 2·13) with a loamy surface over a red clay subsoil; lime nodules occur below about 30cm depth.

C — Major drainage zone.

D — Saline drainage zone associated with Hannan Lake.

E — Tailings drainage zone downslope from tailing stockpiles.

⊙5 Biological sample site.

0 0.5 1 km

Scale from Air Photos approx.

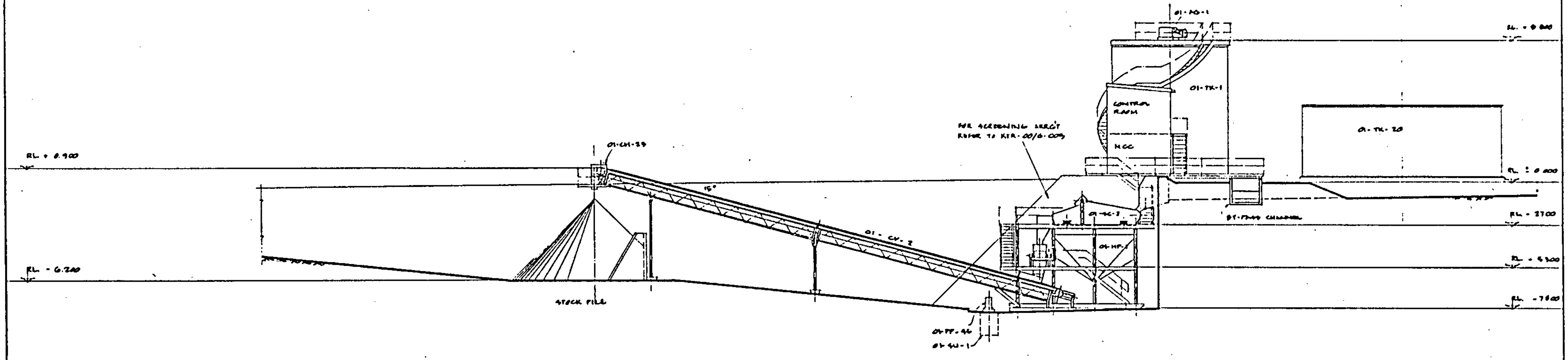
—·— Boundary of forest reserve

REVISIONS			
Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

LANDFORM AND SOILS DISTRIBUTION NEAR LAKESIDE, KALGOORLIE

Date June, 1987 | Dwg. 2034-14 | Fig. 11



SECTION A/003

Dwg. 2034-15 Fig. 12

CLIENT APPROVED for CONSTRUCTION

Drawing No	Reference Drawings
KTR-00/G-003	MONITOR STATION SCREENING ARRG'T
KTR-00/G-001	" " SITE PLAN

MINPROC ENGINEERS PTY. LTD.
22 STIRLING HIGHWAY, NEDLANDS, W.A. 6009
TELEPHONE: 389 1666

PROJECT APPR	G Clay	
DESIGN APPR		
DESIGNED	BWL	
CHECKED	BWL	26.8.87
DRAWN	GRS	25.8.87

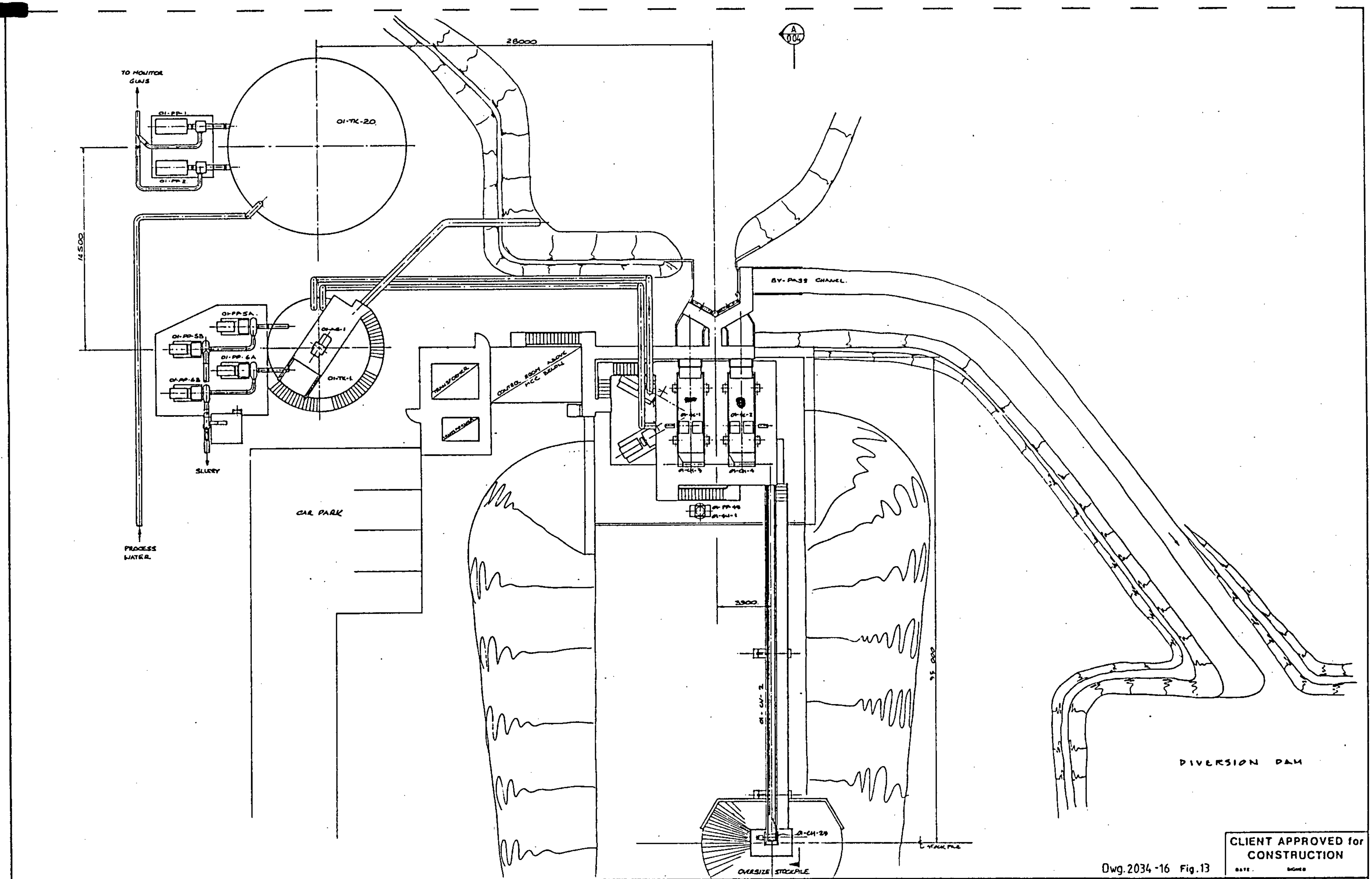
PLANT GRID NORTH

CLIENT: ANGLO AMERICAN PACIFIC LIMITED

SIZE: B1 SCALE: 1:100

TITLE: KALGOORLIE TAILINGS RETREATMENT PROJECT
MONITOR STATION
SECTIONS

DRAWING No: KTR - 00/G - 004



Dwg. 2034-16 Fig. 13

CLIENT APPROVED for CONSTRUCTION

DATE: SIGNED:

KTR-00G-004	MONITOR STATION - SECTIONS
DRAWING No	REFERENCE DRAWINGS

MINPROC ENGINEERS PTY. LTD.

22 STIRLING HIGHWAY, NEDLANDS, W.A. 6009

TELEPHONE: 386 1655

No	BY	DATE	REVISION	CHECKED	APPROV

	BY	DATE
PROJECT APPR	9 CMay	3/11/87
DESIGN APPR		
DESIGNED	BNL	
CHECKED	BNL	20.8.87
DRAWN	[signature]	19 8 87

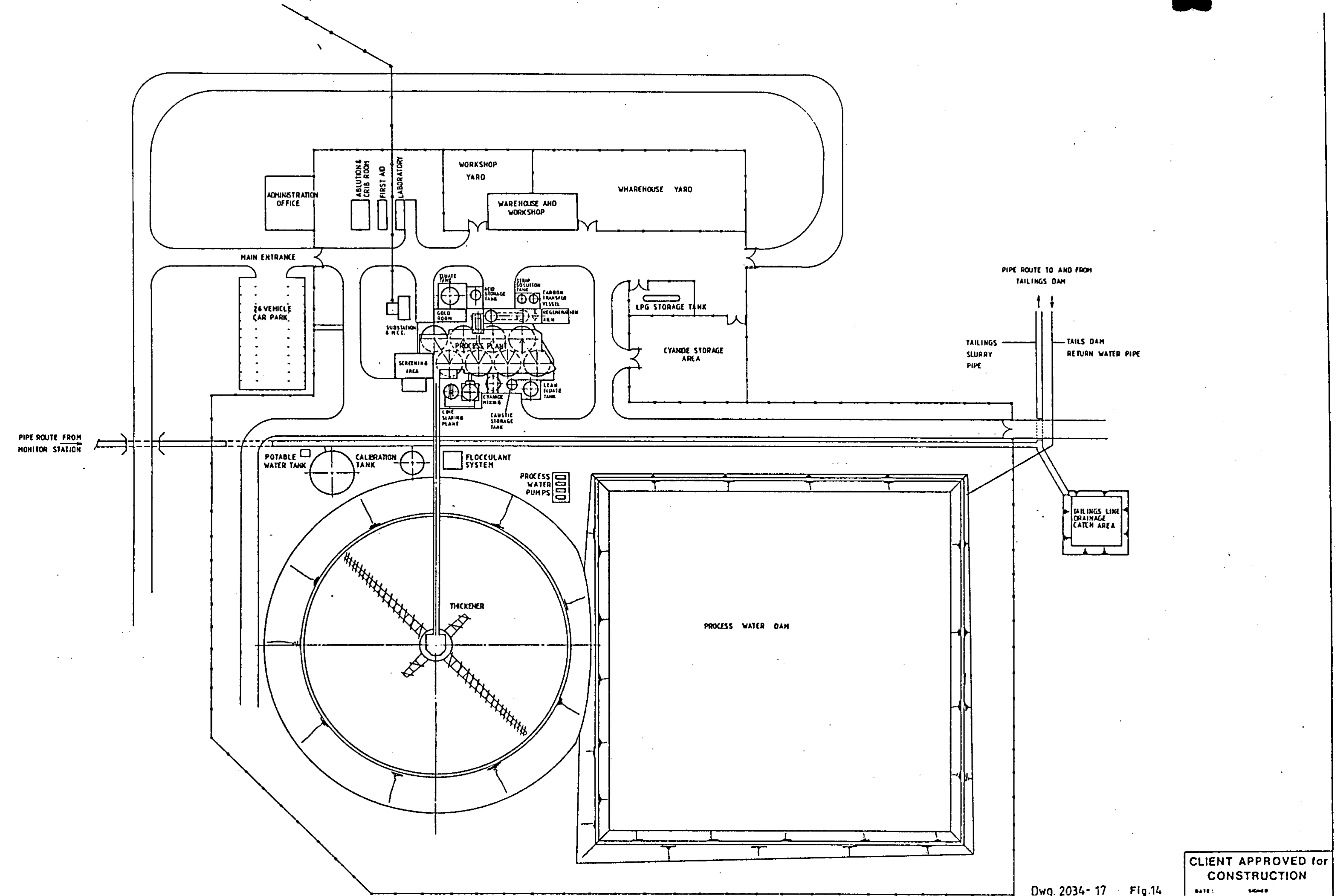
PLANT GRID NORTH

CLIENT: ANGLO AMERICAN PACIFIC LIMITED

SIZE: B1 SCALE: 1:100

TITLE: KALGOORLIE TAILINGS RETREATMENT PROJECT
MONITOR STATION
SITE PLAN

DRAWING No: KTR-00/G-003



CLIENT APPROVED for CONSTRUCTION

DATE: SIGNED

Dwg. 2034- 17 Fig.14

DRAWING No	REFERENCE DRAWINGS

COPYRIGHT ©

This drawing remains the property of MINPROC ENGINEERS PTY. LTD. and may not be copied in any way without prior written approval from this company

MINPROC ENGINEERS PTY. LTD.

22 STIRLING HIGHWAY, NEDLANDS, W.A. 6009

TELEPHONE: 389 1655

No	BY	DATE	REVISION	CHECKED	APPROV	No	BY	DATE	REVISION	CHECKED	APPROV

	BY	DATE
PROJECT APPR	9C May	31/8/87
DESIGN APPR		
DESIGNED	GWL	
CHECKED	GWL	20.8.87
DRAWN	RM	12.8.87

PLANT GRID NORTH

CLIENT: ANGLO AMERICAN PACIFIC LIMITED

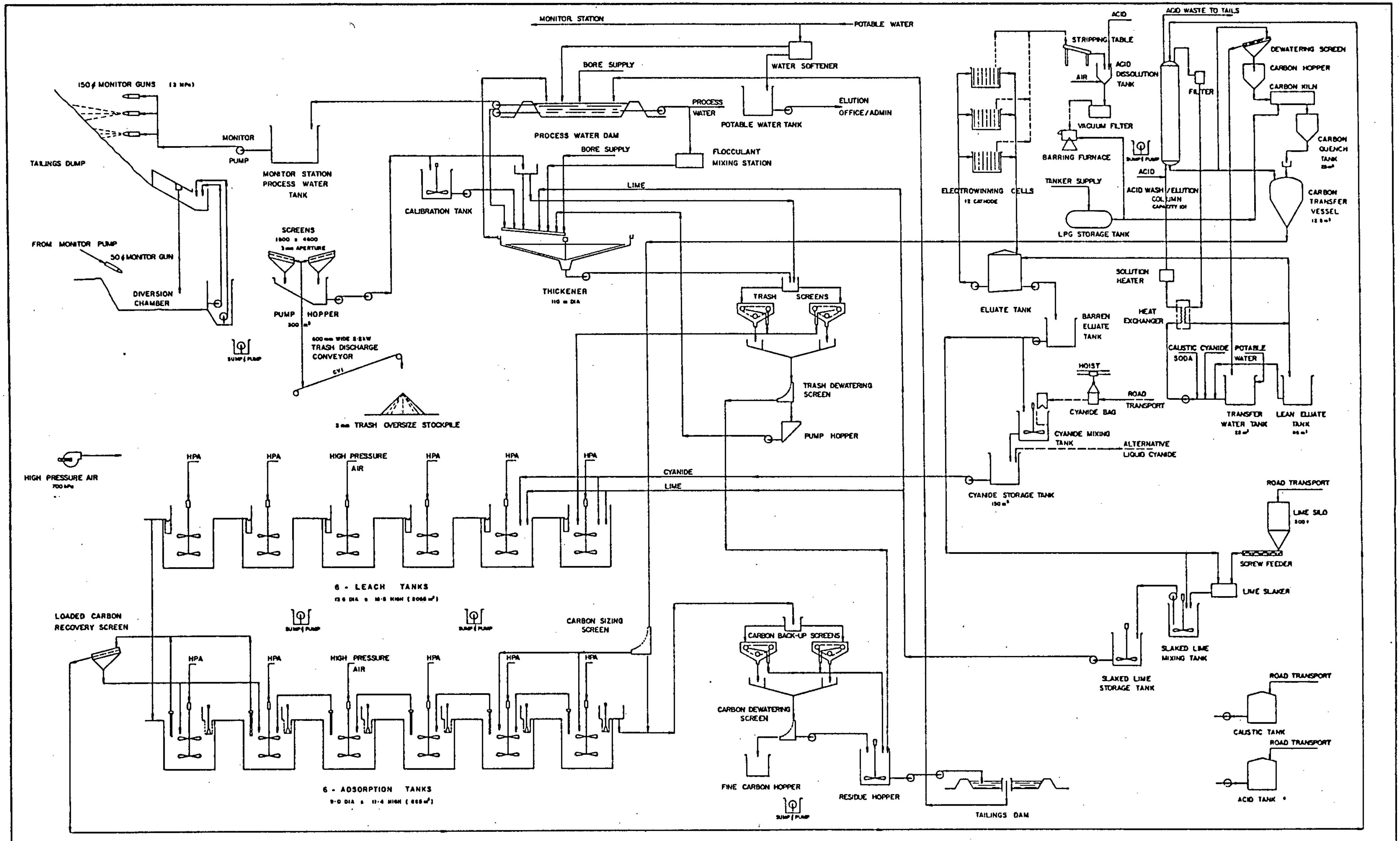
TITLE: KALGOORLIE TAILINGS RETREATMENT PROJECT

PROCESS PLANT - SITE PLAN

SIZE: B1 SCALE: 1:500

DRAWING No: KTR - 00/G - 006

[redacted]



Dwg. 2034-26 Fig 15

CLIENT APPROVED for CONSTRUCTION

MINPROC ENGINEERS PTY. LTD.
22 STIRLING HIGHWAY, NEDLANDS, W.A. 6009
TELEPHONE: 386 1656

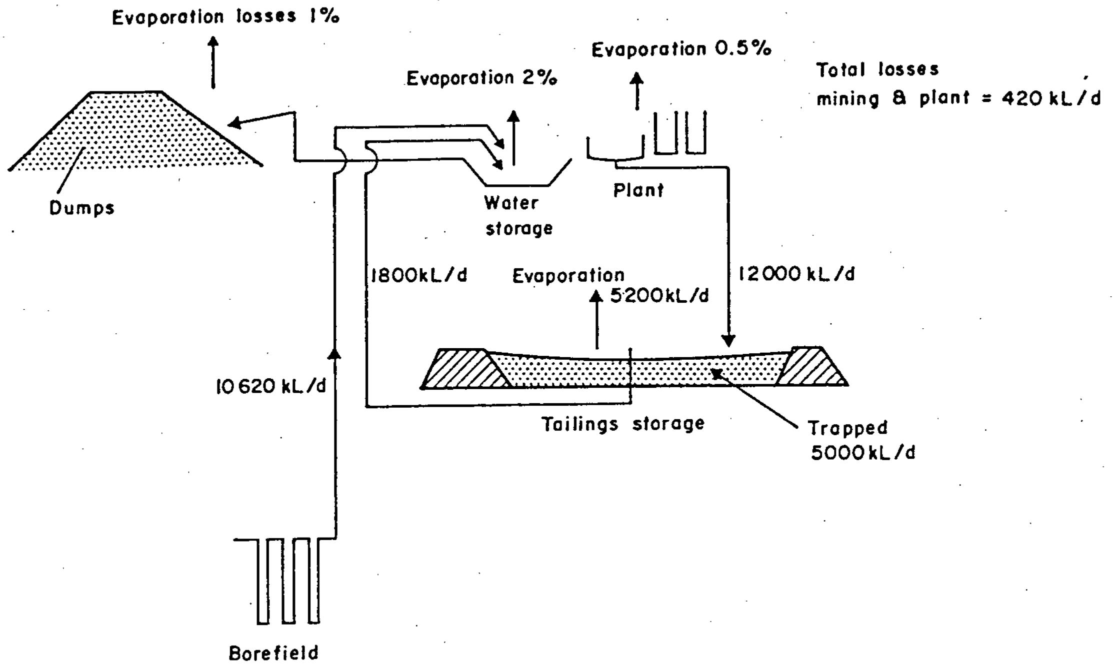
CLIENT: ANGLO AMERICAN PACIFIC LIMITED

B1 N.T.S.

TITLE: KALGOORLIE TAILINGS RETREATMENT PROJECT
GENERAL FLOWSHEET

KTR - 00 / F - 205

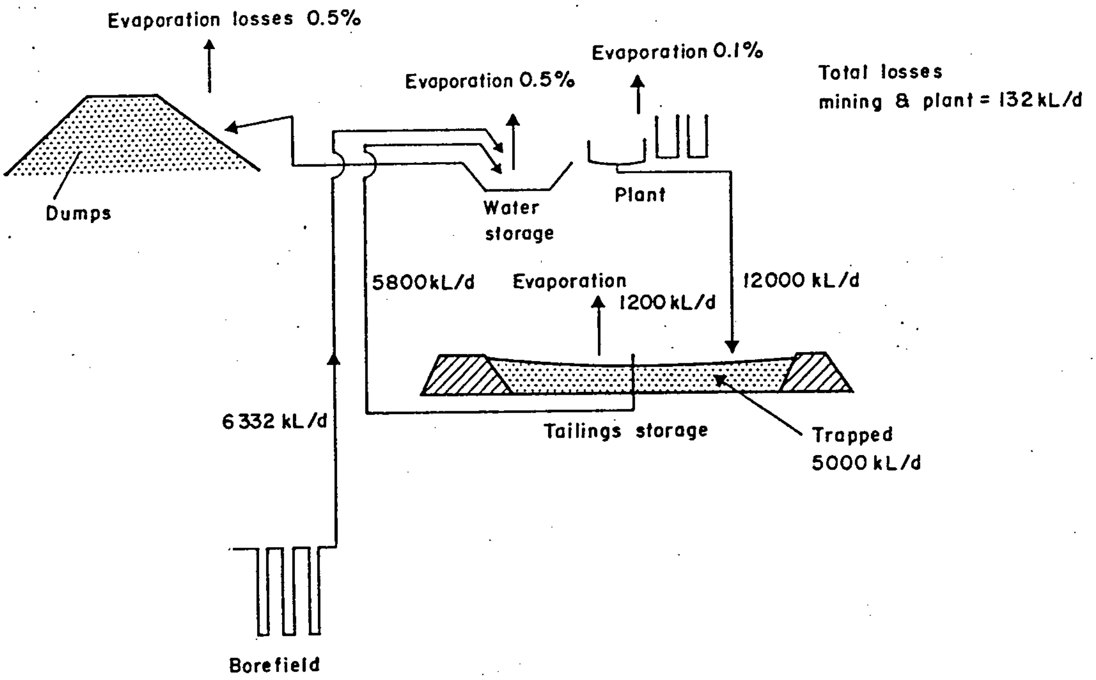
SUMMER WATER BALANCE (JANUARY)



Total losses = 10 620 kL/d

Make up required = 10 620 kL/d

WINTER WATER BALANCE (JULY)



Total losses = 6 332 kL/d

Make up required = 6 332 kL/d

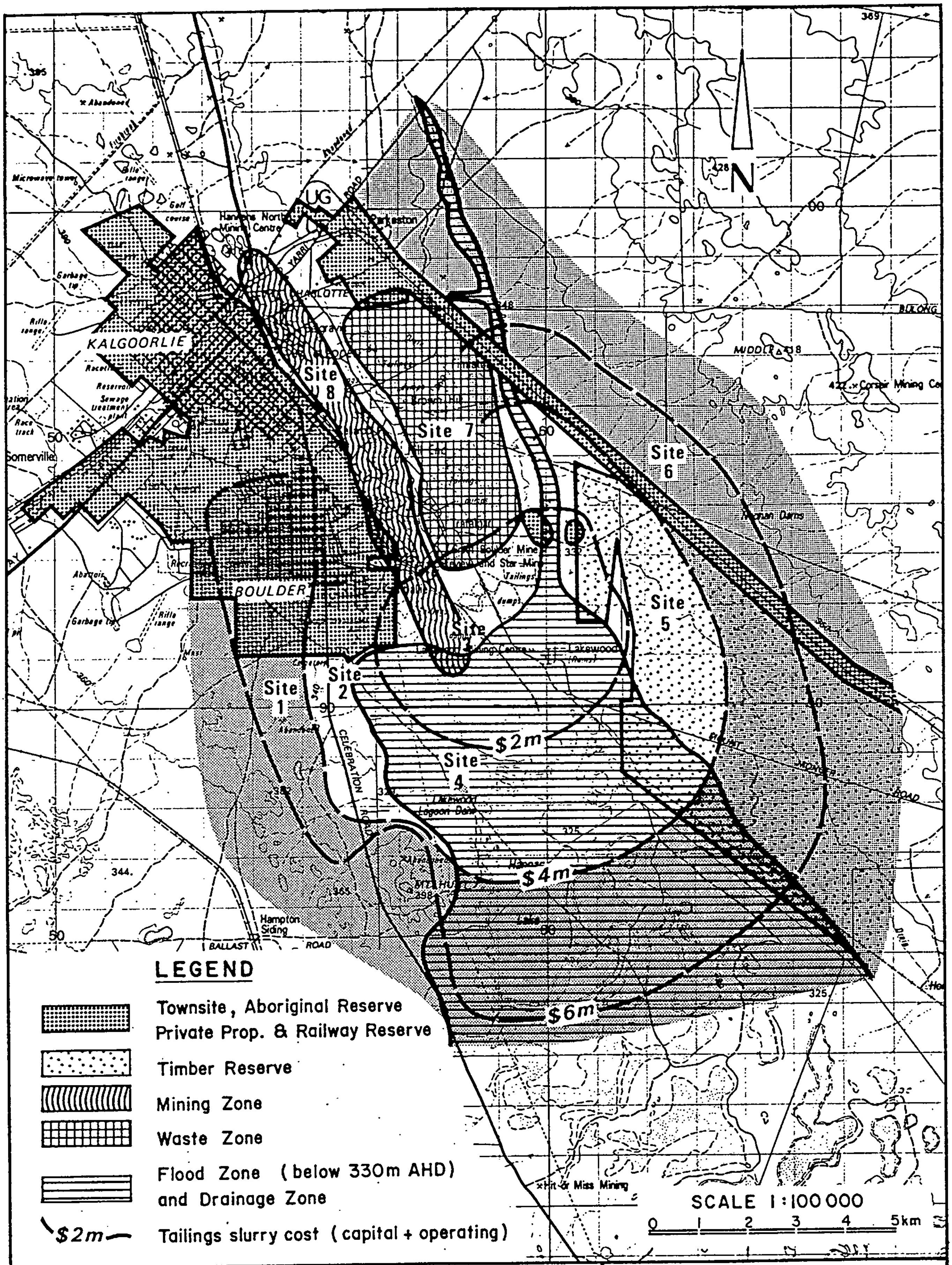
REVISIONS

Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

AVERAGE WATER BALANCE FOR JANUARY AND JULY

Date Aug., 1987 | Dwg. 2034-19 | Fig. 16



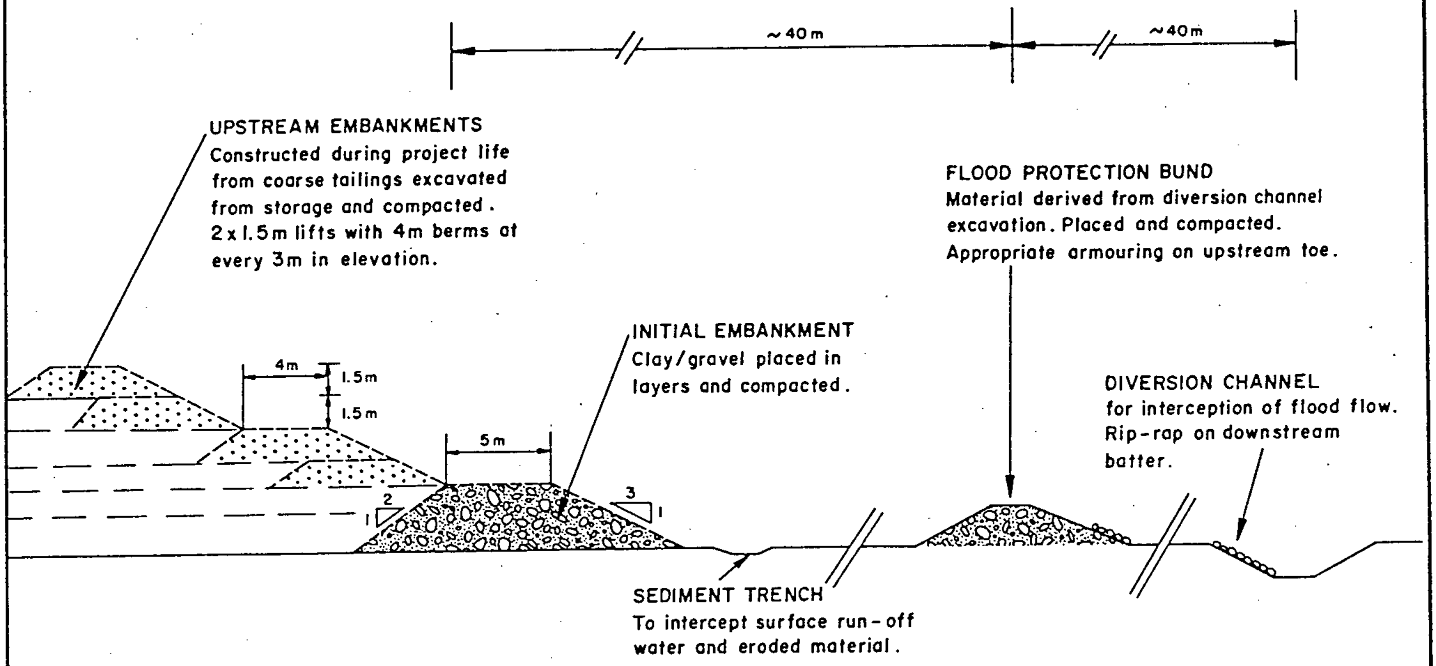
Rev	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

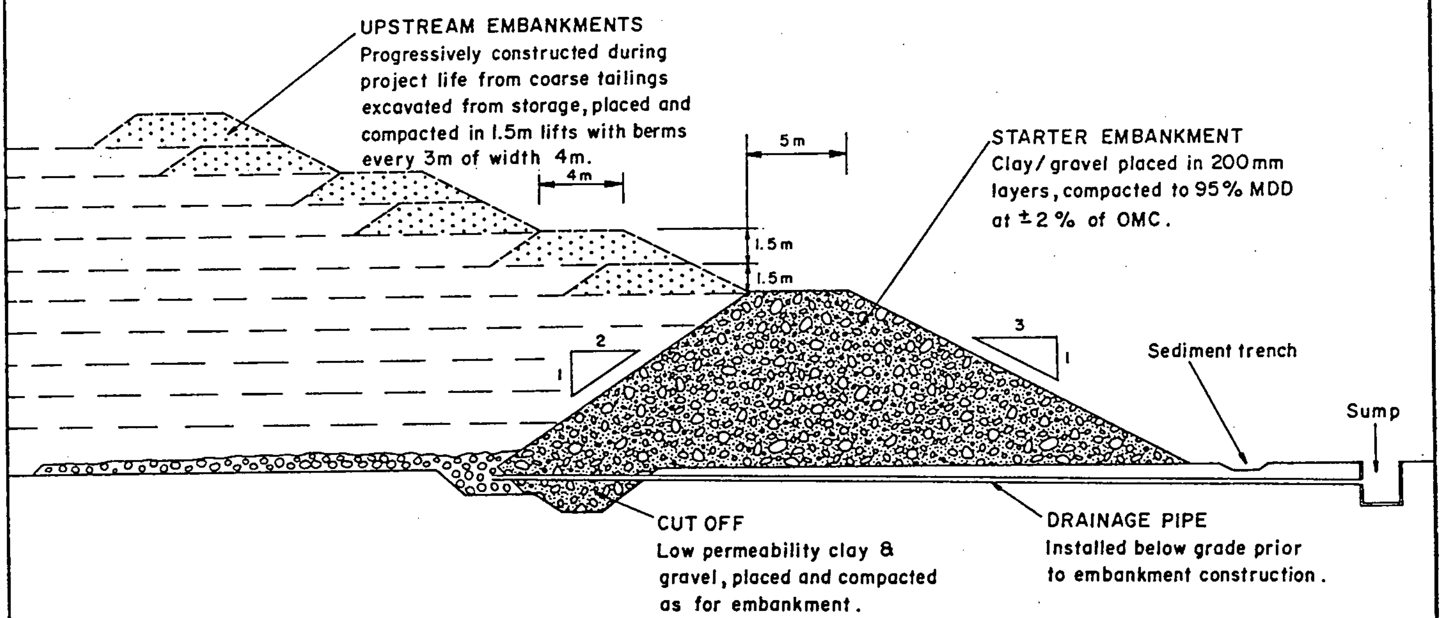
SITE SELECTION FOR NEW TAILINGS STORAGE AND TREATMENT PLANT

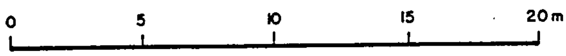
Date JAN'88 | Dwg. 2034-25 | Fig. 17

TYPICAL EMBANKMENT CROSS-SECTION : NORTH EAST CORNER



TYPICAL EMBANKMENT CROSS-SECTION : SOUTH WEST CORNER





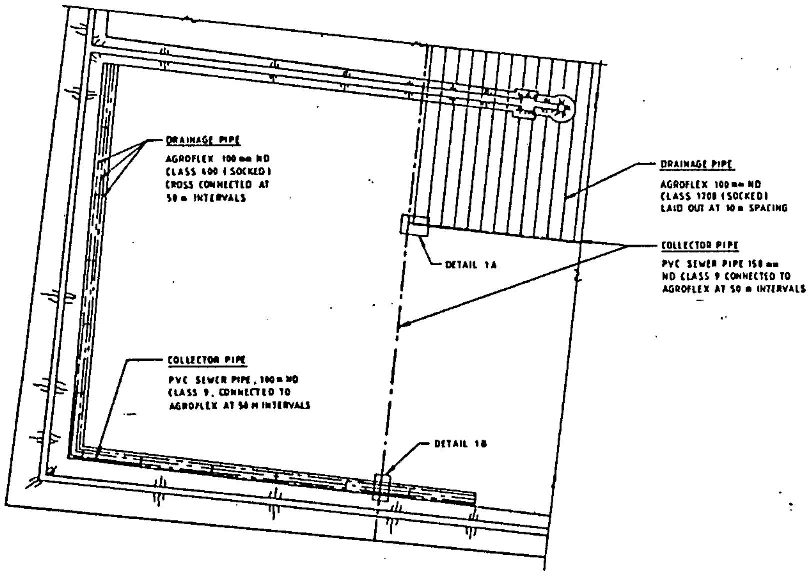
APPROX. SCALE

REVISIONS				
Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

TYPICAL CROSS-SECTION OF TAILINGS EMBANKMENT

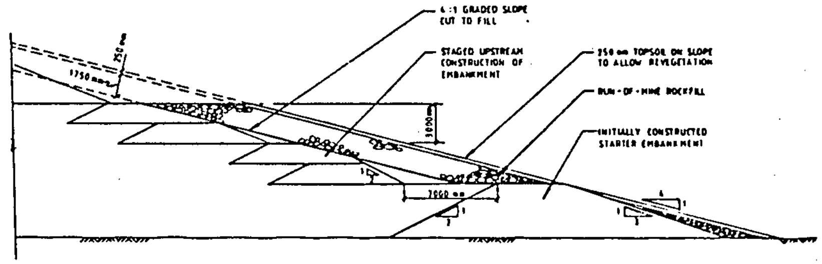
Date June, '87 | Dwg. 2034 - 21 | Fig. 18



DETAIL 1

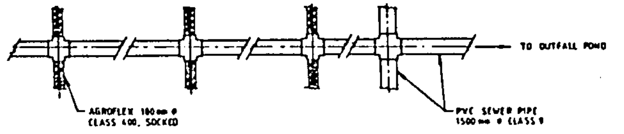
DRAINAGE WORKS AND DECANT TOWER

SCALE 1:2000



PROGRESSIVE SLOPE REHABILITATION

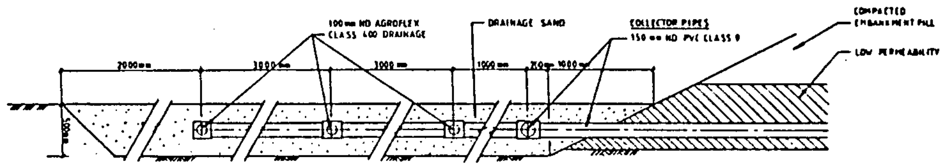
SCALE 1:200



DETAIL 1B

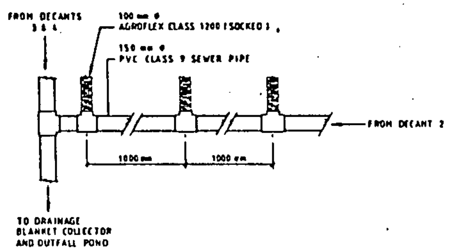
PLAN - PIPING CONNECTIONS

SCALE 1:25



DETAIL 1A

SECTION THROUGH UPSTREAM DRAINAGE BLANKET



DETAIL 1A

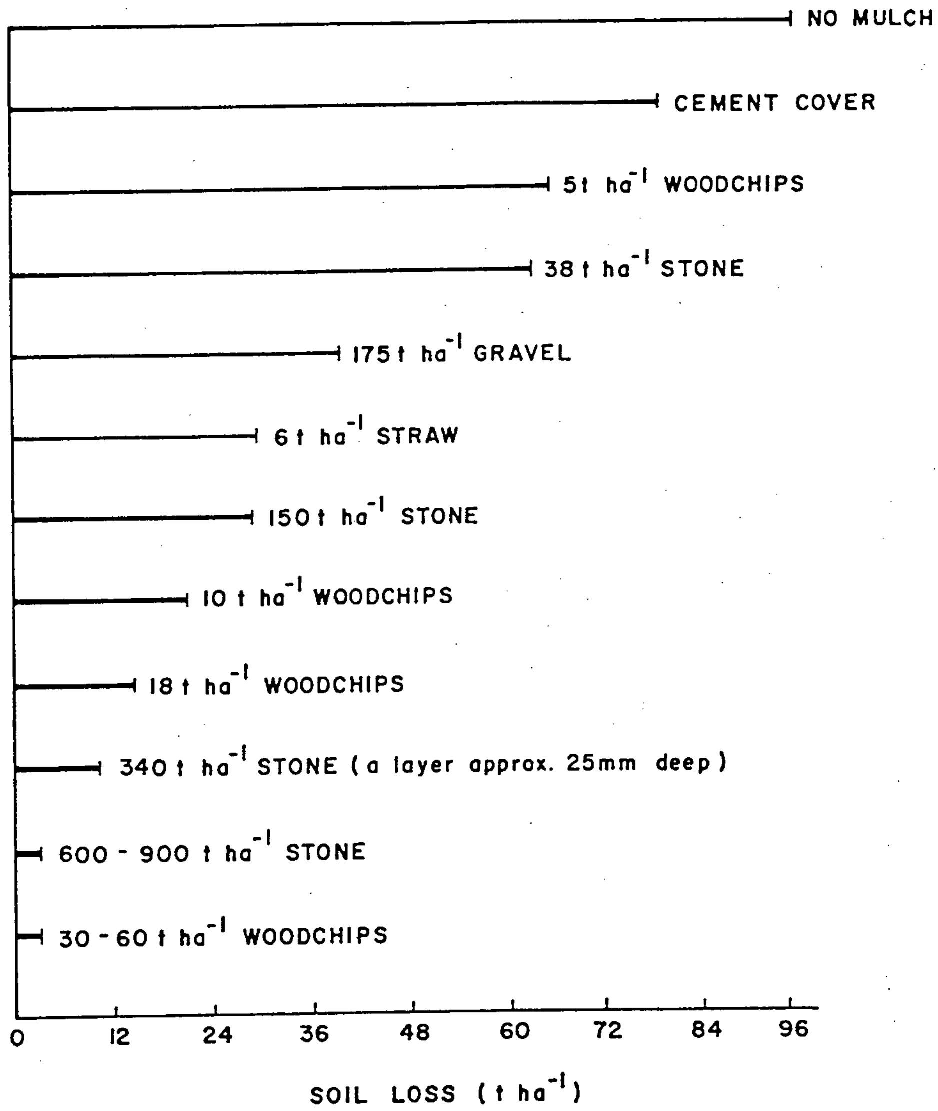
PLAN - UNDERDRAINAGE COLLECTOR SYSTEM

SCALE 1:25

SUBJECT	KALGOORLIE TAILINGS RETREATMENT PROJECT
CLIENT	ANGLO AMERICAN PACIFIC LTD
CONTRACT/ENQUIRY	
SCALE	1:2000, 1:200, 1:25
DRAWN	R.G. 11.8.87
CHECKED	
ENG	
FIG. NO.	19
DWG. NO.	2034-22
REV NO	

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

REVISIONS				REFERENCE DWGS	
REV	DESCRIPTION	DRAWN DATE	CHK'D DATE	DRAWING NO	DESCRIPTION



1. Adapted from Meyer (1972) in Ryan (1987)

2. For the following parameters : Rainfall : 125mm
Intensity : 62.5 mm hr^{-1}
Slope length : 10m
Slope angle : 12°
Soil type : silt loam
Gravel / Stone specifications :
6 - 375mm diam: 50% > 6mm

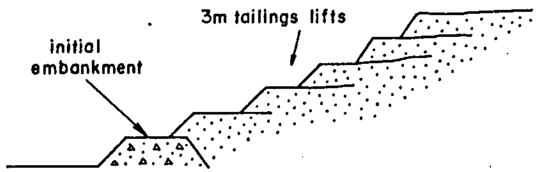
REVISIONS			
Rev.	DESCRIPTION	Drawn Date	Chk'd Date

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

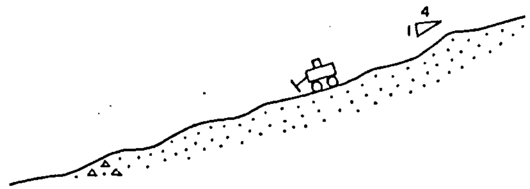
EFFECTIVNESS OF VARIOUS MULCH TREATMENTS

Date June, '87 | Dwg. 2034-23 | Fig. 20

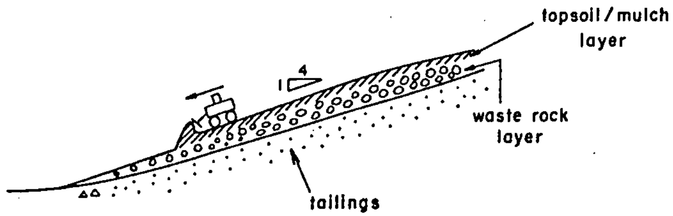
A. PRIOR TO RESHAPING



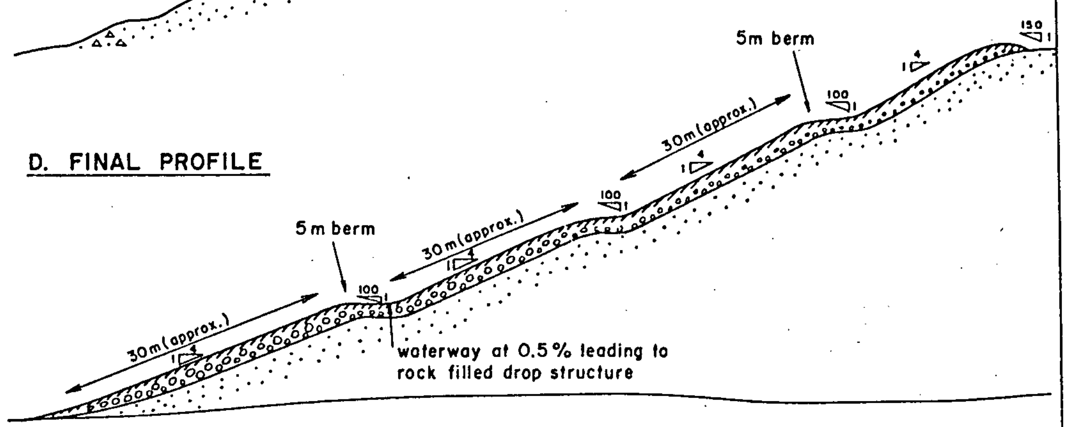
B. RESHAPING



C. COVERING



D. FINAL PROFILE



SCHEMATIC DRAWING

NOT TO SCALE

REVISIONS				
Rev.	DESCRIPTION	Drawn Date	Chk'd Date	

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

PROGRESSIVE REHABILITATION OF THE TAILINGS DISPOSAL AREA

Date June, 1987	Dwg. 2034 - 24	Fig. 21