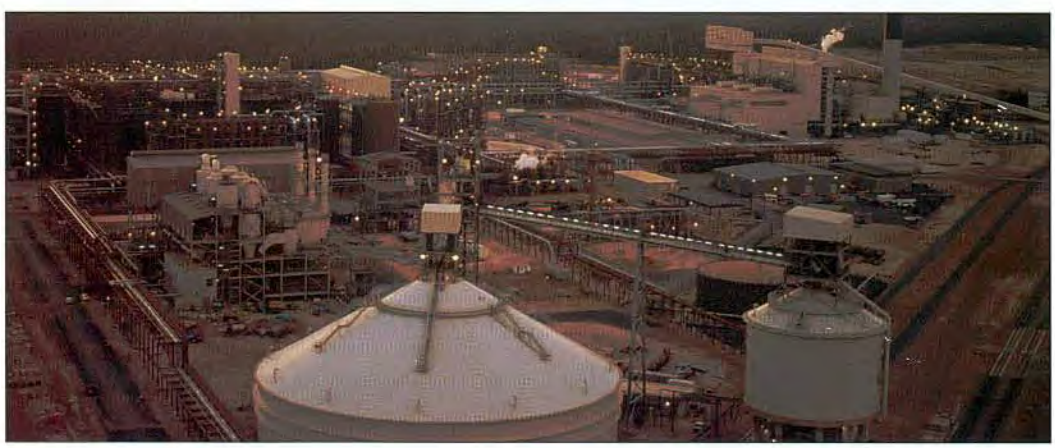
CONSULTATIVE ENVIRONMENTAL REVIEW

WORSLEY BAUXITE – ALUMINA OPERATION

# Proposed Expansion to 3.5 million tonnes per annum Alumina Production



Worsley Alumina Pty. Ltd.

December 1995

# PROPOSED EXPANSION TO 3.5 MILLION TONNES PER ANNUM ALUMINA PRODUCTION

**WORSLEY ALUMINA PTY LTD**

**December 1995**

# AN INVITATION TO COMMENT ON THIS CER

This consultative Environmental review (CER) describes a proposal for Worsley Alumina Pty Ltd to expand their project operations to 3.5 million tonnes per annum alumina production

The CER describes the proposal and its likely effect on the environment in accordance with the requirements of the *Environmental Protection Act, 1986.*

The CER is available for public review for six weeks from 27 December, 1995 to 7 February, 1996.

After receipt of comments from Government agencies and from the public, the EPA will prepare an Assessment Report with recommendations to the Government, taking into account issues raised in public 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 by the EPA will be acknowledged. Submissions will be treated as public documents and may be quoted in full or in part in each report unless specifically marked confidential.

Submissions may be fully or partially utilised in compiling a summary of the issues raised or where complex or technical issues are raised, a confidential copy of the submission (or part of it) may be sent to the proponent.

The summary of issues is normally included in the EPA's Assessment report.

**Why not join a group?**

If you prefer to write your own comments, it may be worthwhile joining a group or other groups interested in making a submission on similar issues.

Joint submissions may help to reduce the work for an individual or group, while increasing the pool of ideas and information.

If you form a small group (up to ten people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

**Developing a submission**

You may agree or disagree with, or comment on, the general issues discussed in the CER or the 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 items in the review document:

- 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 analysed:

- Attempt to list points so that the issues raised are clear. A summary submission is helpful.

- Refer each point to the appropriate section, chapter or recommendation in the CER.

- If you discuss different sections of the CER, 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.

Remember to include:

- your name,
- your address,
- the date, and
- whether you want your submission to be confidential.

The closing date for submission is:

Wednesday, 7 February, 1996

Submissions should be made to:

Environmental Protection Authority
8th Floor, Westralia Square
141 St Georges Tce
PERTH WA 6000

Attention: Mr Shane Sadleir

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# EXECUTIVE SUMMARY

## INTRODUCTION

The present Worsley Project was given approval to proceed in 1980 pursuant to the *Alumina Refinery (Worsley) Agreement Act 1973* (Agreement) and in accordance with the 1979 Environmental Review and Management Programme (ERMP). This Agreement requires a further environmental review when the production capacity of the project exceeds 2.0 million tonnes of alumina per annum.

This Consultative Environmental Review (CER) is for an expansion of alumina production from 2.0 to 3.5 million tonnes per annum and its preparation has been required by the Environmental Protection Authority (EPA) under Part IV of the *Environmental Protection Act 1986.*

The CER addresses environmental issues associated with the expansion and is intended to provide the EPA, Government agencies and the public with an opportunity to advise and comment on Worsley's environmental management proposals. The CER is subject to a six week public review period from 27 December 1995 to 7 February 1996.

The format of this document is very different to previous CER's and reflects a new approach in the presentation of environmental management information preferred by the EPA.

The expansion of the Worsley Project has a number of benefits for Western Australia and Australia including additional export revenue, expenditure of $670 million during construction and increased employment through the creation of an additional 600-700 job opportunities during construction. It is anticipated that 84% of expansion expenditure will be spent on Australian goods and services.

There will also be increased revenue to the Commonwealth, State and local governments through taxes, levies and royalties from the expansion.

## THE EXPANSION

The Worsley Project is located in the south west of Western Australia and presently involves the mining of bauxite in the Mt. Saddleback area, transport of this material on a 51 km overland conveyor to the refinery where alumina is extracted from bauxite by the Bayer process. Bauxite residue or "red mud" is a by product of the Bayer process and is disposed of onsite, in contained impoundment areas.

The mining of bauxite presently takes place in the Primary Bauxite Area (PBA) near the town of Boddington within Worsley's mining leases granted under the *Mining Act* and the Agreement Act. Under the expansion, mining will proceed at an accelerated rate within these leases and in approximately 30-35 years mining will go beyond the PBA and into southern and northern parts of mining lease ML 258SA. Based on current proven bauxite reserves up to 65% of the forested area in the PBA will be left uncleared during mining.

To accommodate the increased output of bauxite from the mine, the overland conveyor will be operated for longer hours.

The expansion of refinery capacity will be achieved through the introduction of improved efficiency and by retrofitting existing equipment and installing new process facilities. New plant of environmental significance will include:

- a liquor purification facility to improve the efficiency of the Bayer process;
- either a coal or gas fired boiler to provide for the additional energy demand of the expansion; and
- two additional gas fired calciners to remove chemically combined water to form alumina product.

Production of bauxite residue will increase proportionally and will require an acceleration of the construction program for residue disposal areas. No extension of the area originally approved for residue disposal will be required to accommodate the expansion for present proven bauxite reserves within the PBA. The refinery and residue disposal areas are designed so that contaminated water does not escape from the refinery lease area. Contaminated runoff waters and seepage from the residue disposal areas are captured by pipehead dams and the refinery catchment lake for use in the refinery process. Fresh water on the refinery lease is directed to the freshwater lake for potable uses in the refinery and as make up water to the refinery process.

An extensive network of monitoring bores and sites around the refinery have been established to monitor any affects on the quality of groundwater and surface waters.

The anticipated annual increase in mining, atmospheric emissions, and bauxite residue associated with the expansion, are as follows:

| | **2 Mt/a Production** | **3.5 Mt/a Production** | **Increase** |
|---|---|---|---|
| bauxite mined | 7.3 | 12.6 | 5.3 million tonnes |
| bauxite residue | 6.8 | 11.9 | 5.1 million wet tonnes |
| sulphur dioxide | 10,610 | 16,370 | 5760 tonnes (with coal as fuel) |
| oxides of nitrogen | 4,310 | 6,650 | 2340 tonnes |
| particulates | 293 | 512 | 219 tonnes |
| carbon dioxide | 1,960 | 3,150 | 1.2 million tonnes (with coal as fuel) |

While the above increases are anticipated, the specific rate of consumption of energy will decrease by 10%, resulting in lower rates (11-15%) of atmospheric emissions per tonne of alumina produced.

Increased water consumption in the refinery will be met in the medium and longer term by increasing the yield from the refinery catchment and by the recovery of recycled water.

A small amount of native vegetation (3 hectares) within the refinery lease area will be cleared to accommodate the expansion of the refinery.

## THE EXISTING BIOPHYSICAL ENVIRONMENT

The bauxite mine is located in the eastern Darling Range forest where the annual rainfall averages 740 mm. The PBA lies within the Darling Botanical District of the South Western Botanical Province and can be considered as consisting of three areas:

- Saddleback area with 12 vegetation units and 374 species of flora;
- Marradong area with 9 vegetation units and 290 native species of flora; and
- Hotham North which is presently being surveyed.

In these areas no rare and endangered flora have been located, but 15 priority species from CALM's Declared Rare and Priority Flora have been recorded to date. Within the Saddleback Timber Reserve the Tunnell Road heathland is considered to have local and regional environmental values and consequently mining has been minimised in this area.

The moderately saline Hotham River flows through the PBA and has limited value as a public water supply.

A number of permanent residences are in proximity to the mine and the overland bauxite conveyor.

The overland conveyor traverses the Darling Plateau, in predominantly State Forest, from north east to south west passing from low to high rainfall zones. The vegetation communities along the route of the conveyor closely match the variation in rainfall, and generally become more dense and higher in the higher rainfall western Darling Range.

The refinery is located in an area of historically-logged jarrah forest in the headwaters of the Brunswick and Augustus Rivers. The environmental values of water resources in these areas include aquatic ecosystems and public water supply. Groundwater in the area is fresh and generally discharges along creek lines low in the landscape of the catchment. The closest permanent residence to the refinery is approximately 8 km away.

## ENVIRONMENTAL IMPACTS AND MANAGEMENT

An extensive scoping procedure to determine environmental issues of potential concern or importance to the public, community organisations, local authorities, Members of Parliament and Government agencies has been undertaken by Worsley as part of the

environmental impact assessment process. Included in this process was an independent survey (involving face to face and telephone interviews) of 281 persons in the vicinity of the mine and refinery. While this survey provided information on environmental issues of potential concern, the vast majority of respondents regarded Worsley's environmental management in a positive light and thought that Worsley should be able to expand.

Environmental issues of concern to local and broader communities and government authorities, determined by survey or through direct consultations, were used to formulate a number of environmental topics which became the framework for this impact assessment. For each environmental topic an objective has been developed to indicate the outcome to be achieved by Worsley's environmental management.

Under each topic the environmental requirements (whether statutory or policy), potential impacts, past environmental performance, impact assessment and management and commitments are discussed.

**Worsley's Environmental Management Approach**

Irrespective of the environmental objectives to be achieved for each topic, Worsley is committed to achieve excellence in environmental management wherever practicable by continuously improving environmental performance. Worsley is integrating environmental issues into routine components of project planning and operations such that every employee takes responsibility for the environmental management component of their own work.

Worsley has implemented an environmental management system which is comprised of five broad programs as follows:

- Environmental Education;
- Environmental Services;
- Environmental Studies and Investigations;
- Environmental Monitoring and Auditing;
- Environmental Reporting;

Implementation of these programs is facilitated through Worsley's environmental compliance system and its community and Government liaison.

Worsley's environmental planning, monitoring, auditing and investigative activities are formulated and reported to the State in accordance with Worsley's existing environmental commitments. This process is facilitated through the Environmental Management Liaison Group (EMLG), which is a multi-disciplinary group comprising representatives of key Government agencies.

The EMLG and Worsley's objectives in the liaison process are to meet Worsley's statutory obligations.

## Bauxite Mining

### *Conservation of Flora and Fauna*

The clearing of native vegetation has the potential to affect biodiversity and rare flora and fauna of eastern Darling Range forest ecosystems in the short term. To prevent any such effects Worsley will continue to implement a conservation strategy which involves the following elements:

- Undertake baseline flora and fauna surveys prior to mining in new areas;
- Educating the workforce on the importance of flora and fauna and the strategies to protect them;
- To not adversely affect significant plant communities and designated priority flora from mining;
- To not adversely affect rare and endangered fauna from mining; and
- Rehabilitation of mined land to re-establish eastern Darling Range forest ecosystems.

Worsley expects that the expansion will not impact on rare and endangered species or biodiversity of the eastern Darling Range jarrah forest in the long term.

### *Rehabilitation*

Areas in which mining is undertaken may include both Crown and private land. Different approaches are taken by Worsley for the rehabilitation of private and Crown land because of the varying purposes of the land. Worsley rehabilitates forested Crown land in accordance with rehabilitation prescriptions developed in consultation with CALM. The aim in these areas is to regenerate a forest ecosystem with flora and fauna characteristics comparable to that which existed prior to mining.

Rehabilitation is a major component of Worsley's strategy to conserve flora and fauna. To facilitate successful rehabilitation the direct return of topsoil is maximised and the area cleared for mining operations is minimised.

The effectiveness of rehabilitation is regularly monitored and establishment criteria have been developed with CALM to ascertain the performance of rehabilitation. Rehabilitation in mined areas has to date exceeded these criteria.

Recolonisation by fauna in rehabilitation areas is monitored and has shown that the pygmy possum and the common dunnart can be found in rehabilitated areas. Recolonisation by fauna is encouraged with the creation of faunal habitats by returning forest debris to rehabilitation areas.

Worsley has embarked on a process of preparing completion criteria which will determine the progress of rehabilitation and the stage when the management of rehabilitated land can be returned to CALM.

A total of 568 hectares of land that has been disturbed by mining to date is being rehabilitated.

Under the Agreement, compensation arrangements for mining, and rehabilitation or restoration programs are reached on a case by case basis with private land owners. A catchment management approach has been adopted by Worsley for the rehabilitation of mined farm land and rehabilitation programs are developed in consultation with the Department of Minerals and Energy and the Department of Agriculture.

***Forest Disease Management***

The incidence and spread of jarrah dieback is anticipated to be low in the eastern Darling Range forest because of the low rainfall, hot dry summers and well drained soils. Two small infections (less then one hectare) of jarrah dieback have been detected in the mining area, both of which pre-date mining.

Worsley will continue to implement forest hygiene measures which include:

- the application of forest hygiene prescriptions approved by CALM;
- mine planning based on disease risk minimisation;
- workforce education;
- rehabilitation of disease areas where required; and
- supporting research relevant to improving forest disease management.

To date Worsley's forest disease management strategy has been effective in minimising the risk of spread and introduction of forest diseases associated with mining activities.

***Integration with CALM Forest Management***

Worsley works closely with CALM to ensure the maximum salvage of the timber resource in areas scheduled for mining. The management of forest within the PBA is conducted in accordance with CALM's forest management plans and Worsley participates in joint operations, including fire management and feral animal control.

Both CALM and Worsley are committed to a fire protection strategy through the Worsley-CALM Hazard Reduction Burning and Wildfire Suppression Agreement. Integration with CALM forest management also ensures that any potential impact on other forest users from Worsley's operations is minimised.

Relinquishments of areas of conservation significance are determined jointly by Worsley and CALM from Worsley's mining lease areas. Areas of proposed conservation reserves excluded or relinquished from mining lease ML 258SA so far totals 551 $km^2$;

***Water Resource Protection***

Before bauxite mining commenced there were concerns that mining would exacerbate salinity problems in the nearby Hotham River catchment. The salinity levels in the Hotham River have been elevated for sometime and are a result of extensive clearing of native vegetation predominantly in the upper catchment for agriculture.

Analysis of monitoring results upstream and downstream from the mine reveals that forest clearing for mining is not significantly affecting the water quality of the Hotham River. The expansion of mining is unlikely to adversely affect salinity levels in the Hotham River.

Water for dust suppression is currently drawn from aquifers beneath the Tunnell Road heathland. Monitoring and investigations of these aquifers have shown that this heathland has not been adversely affected by abstraction and the heathland itself is not dependent on the aquifer. Expansion of mining should not adversely affect this heathland.

Some residents in the vicinity of the mine have expressed a view that blasting may have caused cracks to develop in farm dams. This is highly improbable because the soils and surface rocks in the PBA do not transmit blasting shockwaves at all well.

***Noise Management***

There are several sources of noise in bauxite mining operations. The most significant of these result from:

- blasting;
- mobile mining equipment; and
- fixed equipment such as crushers and conveyors.

The Environmental Noise Model (ENM) computer software has been used to determine mining noise levels in adjoining areas under a number of typical operating conditions.

The sound level at each of 10 nearby residences under a variety of wind speed and direction conditions has been estimated by the ENM. The results of this modelling show that by modifying mining operations at night and reducing noise emissions from mining equipment, noise limits can be met.

An inhouse target for blast noise has been set 15dB (lin) peak below the statutory standard of 125 dB(lin) peak.

In the past where the 115 dB (lin) peak has been exceeded corrective action has been taken and incorporated into blasting procedures.

Worsley uses potential noise emissions as a major criterion in the selection of mining equipment and has implemented a program to progressively reduce noise emissions.

***Dust management***

Worsley applies water to haulroads and other areas that may give rise to dust emissions and has adopted dust level guidelines used by DEP as inhouse standards.

***Public Access and Safety***

Public access to active mining areas or mine haulroads is restricted for safety reasons, however this is done in a manner that will not unnecessarily inconvenience or limit public enjoyment of forest recreation areas adjacent to mining areas. Special measures are implemented in mine areas where there is the potential for significant risk from blasting, mine pits and mine traffic.

**Overland Bauxite Conveyor**

***Forest Protection***

Monitoring suggests that the operation of the conveyor does not have any significant impact on the forest. Environmental management measures have been successful in avoiding impacts on the forest. These measures include:

- restricted access and use of the conveyor corridor;
- fire protection;
- minimisation of clearing and timely rehabilitation of disturbed areas;
- implementation of forest hygiene prescriptions approved by CALM; and
- drainage management.

Two small isolated outbreaks (less than one hectare in area) of jarrah dieback disease have been detected near the conveyor. These are thought to have originated from previous logging operations or construction of the conveyor.

***Noise Management***

Noise standards to be met at a particular distance from the conveyor are prescribed by the *Alumina Refinery (Worsley) Agreement Act 1973*. The conveyor may operate for 24 hours per day provided these standards are met. Since 1993 Worsley has

negotiated agreements concerning noise emissions with land owners nearest to the conveyor.

Extensive investigations of noise sources on the conveyor have been undertaken and modifications to conveyor equipment have been made since 1989 to reduce noise emissions in proximity to noise sensitive areas. The replacement of the hard plastic rim of pulleys on the conveyor with soft rims has resulted in a substantial reduction (10 dBA) in noise emissions from the conveyor. The expenditure on these and other modifications to suppress noise emissions from the conveyor has totalled $11 million.

For the vast majority of the time, noise levels are well below the prescribed standard and Worsley's inhouse noise management policy is to control conveyor noise so that it does not exceed this standard.

Worsley will continue as far as practicable to reduce noise emissions from the conveyor adjoining noise sensitive areas. However, further noise reductions will be proportionately more difficult to achieve and may not be technically feasible.

**Refinery and Bauxite Residue Management**

***Atmospheric Emissions***

The impact of $SO_2$ emissions from the expansion has been determined using AUSPLUME and the morning fumigation model of Dearorff and Willis and assumes as a worst case, that coal will be used as fuel in the power-house. Modelling of $SO_2$ emissions also takes into account the contributions of the Collie and Muja Power Stations.

The results of the AUSPLUME modelling shows that the concentrations of $SO_2$ in the buffer area and at the nearest residence are well below accepted relevant short and long term air quality objectives specified in the Environmental Protection (Kwinana) (Atmospheric Wastes) Policy, 1992. Under fumigation conditions the worst case ground level concentrations of $SO_2$ would exceed the hourly residential objective at a distance of six kilometres only under extreme meteorological conditions which would occur less than once per year.

The expansion may result in an increase in the emission rate and ground level concentrations of sulphur dioxide ($SO_2$) from the burning of additional coal in the powerhouse at the refinery. If natural gas is used as the fuel in the new boiler in the powerhouse there would be no increase in $SO_2$ emissions from the refinery.

Similarly, modelling of NOx emissions has shown that ground level concentrations of NOx are estimated to be well below ambient objectives established by the AEC/NHMRC.

Particulate emissions from the calciners and the powerhouse are controlled by electrostatic precipitators and fabric filters. Dust suppression equipment is employed for the loading and unloading facilities for alumina, lime and coal at the refinery site.

Emissions of volatile organic compounds from the liquor purification facility are expected to be small and well below threshold limit values.

In addition to ensuring that ground level concentrations of air contaminants are acceptable, Worsley is committed to the implementation of a monitoring program to validate model predictions and to incorporate best practicable pollution prevention equipment in new plant or refit of existing plant.

Given the large distances (more than eight kilometres) to the nearest residence, the impact of odours from the expansion is anticipated to be minimal. The independent survey of the nearby residents confirms that odours from the refinery are not a significant concern.

***Water Resource Protection***

Adverse impacts on the environmental values of the adjoining Brunswick and Augustus Rivers downstream of the refinery are prevented by:

- The conservative design of the refinery contaminated water containment system and the impoundments for bauxite residue;
- Implementation of a spills and stormwater management plan which includes:
    * containment of spills and contaminated runoff;
    * extensive onsite and offsite monitoring;
    * recovery and cleanup of spills onsite;
    * regular inspections of the condition of plant and equipment;
    * a system of reporting spill events; and
    * education and training of employees.
- Maintenance of basal summer flow from the freshwater lake.

Monitoring carried out to date indicates no significant adverse effects have occurred on the environmental values of areas downstream of the refinery lease and there are none expected as a result of the expansion. Any spills that have occurred within the refinery area have been swiftly cleaned up and have not caused any offsite impacts.

***Management of Bauxite Residue Disposal***

A pollution prevention approach has been adopted in the design and management of bauxite residue containment. This approach involves minimising the amount of alkaline substances held in the residue impoundments, by filtration of the residue prior to disposal and by incorporating an underdrainage system beneath the impoundments

to recover alkaline seepage for reuse in the refinery process. This and other design features minimise the risk of failure of clay seals and provide for recovery of any leakage that does occur.

The design and performance of the residue impoundments has proven to be effective. Only one localised seepage from the clay seal has occurred but this did not result in a leakage to the environment.

The viability of alternative uses of bauxite residue appear limited but Worsley is presently defining the characteristics of residue for use as a soil amendment agent and a nutrient adsorption medium.

The process of residue deposition results in wet residue surfaces largely mitigating dust emissions from residue areas, and rehabilitation of residue areas will commence immediately these areas become available. Dust emissions will be controlled to statutory and recognised environmental standards.

Closure criteria and a long term management strategy for residue areas will be developed by Worsley in consultation with the Environmental Management Liaison Group.

This group is comprised of a panel of government experts representing key regulatory agencies with statutory responsibilities for environmental aspects of the expansion.

***Hazard Management***

The principal hazard associated with the refinery is the handling of large quantities of caustic soda at elevated temperatures and pressure. The main danger of this material is to personnel who work in the plant. Worsley have developed a comprehensive safety awareness program and a system of incident reporting which ensures a review and appropriate preventative action is taken.

Worsley has also developed an emergency response plan for hazardous materials. This plan covers aspects of incident management, including safety, notification of authorities and clean up measures.

Worsley's hazard management has been recognised by awards from the Institute Foundation for Accident Prevention.

**Waste Management**

Worsley has developed a waste minimisation strategy at the bauxite mine and the refinery. The main aims of this strategy are to minimise the generation of waste, as well as to recycle or reuse as much waste as is practicable. At the refinery sodium oxalate produced as a by-product of the Bayer process is broken down by a bioremediation process into harmless products. Worsley is confident that the sodium sulphate produced by the liquor purification process in the expansion can be marketed as a feedstock for other chemical processes.

The landfill managed by Worsley on the refinery lease is operated under stringent controls to ensure waste is both minimised and disposed of in an environmentally acceptable manner.

### Greenhouse Gases

A greenhouse gas inventory conducted by independent consultants shows the major source of greenhouse gases is from the burning of coal in the power house boilers. Total greenhouse gases from Worsley's existing operations amounts to 1.75 million tonnes per annum.

This inventory study also demonstrates that the bauxite mine becomes a greenhouse sink (net consumer of carbon dioxide) by the year 2009 owing to rapid biomass production within rehabilitated areas.

Worsley is committed to reducing as far as is practicable greenhouse gases from its operations by:

- participation in industry wide agreements;
- increased energy efficiency;
- rehabilitation and reduced burning of forest material;
- preservation of greenhouse sinks on Joint Venture owned land;
- contributions to landcare and reafforestation elsewhere;
- phasing out the use of halon fire extinguishing equipment; and
- investigate and where practicable, use alternative fuels.

### Implications of Climate Change

The potential changes of climate that may occur in the south west have been estimated by CSIRO and will been considered in the detailed design of the expansion. The most important influence on the performance of the project will be changes in rainfall and consequent runoff.

These climatic changes are not likely to affect the operations of the expanded project. However, Worsley will monitor the development of climate change investigations and incorporate any relevant information into the project planning process (ie rehabilitation).

### Decommissioning and Return of Rehabilitated Land

Decommissioning of plant and equipment associated with bauxite mining, the overland conveyor and the refinery is unlikely to take place for a long time. Bauxite in mining

lease ML 258SA is sufficient to maintain the production of alumina well beyond the 30-35 year life of the Primary Bauxite Area.

The decommissioning of individual bauxite residue impoundments will occur periodically in the future and as decommissioning occurs the process of rehabilitation will commence. Worsley would anticipate that these areas will remain under its management control until the refinery is decommissioned.

Mined land is being rehabilitated and these areas will remain the responsibility of Worsley until they are returned to CALM. The return of rehabilitated land will occur when it is demonstrated that the rehabilitation meets the completion criteria agreed to by the State.

Worsley has commenced the process of establishing completion criteria for rehabilitated mined land and a closure strategy for residue disposal areas. Given that these matters are of interest to many Government agencies, Worsley supports the formulation of these criteria in conjunction with the Environmental Management Liaison Group.

## SOCIAL ENVIRONMENT AND MANAGEMENT

### Mining

Bauxite mining occurs in proximity to the town of Boddington. The Boddington Shire, as a result of gold and bauxite mining development, has experienced a doubling of its population since 1981, together with a large increase in the proportion of the population who are in the workforce.

The highest proportion of the workforce in the Shire is employed in the mining industry. The unemployment rate is relatively low. The majority (almost 70%) of the bauxite mine workforce reside in the town of Boddington with the remainder residing in other towns in the region or in Perth or Mandurah.

The expansion is not anticipated to result in a significant construction workforce but the operational workforce may increase by up to 55 persons. The additional workforce can be readily accommodated in the Shire and the impact of this increase on community facilities and services is anticipated to be minimal.

Worsley has, at each stage of mining development and through assistance programs, contributed to the provision of community facilities. Subject to periodic review, Worsley is committed to the continuation of existing assistance programs.

The increased mine traffic from the expansion adds only marginally to the existing volumes of traffic on major roads in the area. These roads are all sealed, in reasonably good condition and constructed to a capacity in excess of the present traffic volumes.

## Refinery and Overland Conveyor

The increase in the operational workforce may be up to 100 persons and the peak level of the construction workforce is anticipated to be approximately 600-700. The additional operational workforce can be readily accommodated in the region. However in relation to the construction workforce, depending on the extent of recruitment from the region, short term accommodation presently available in the region may be inadequate.

If sufficient short term accommodation is not available, Worsley will provide construction camp accommodation near the refinery.

### *Rail and Road Traffic*

Depending on the size of trains used for unloading and loading of product and raw materials, some increase in train movements are anticipated. Early advice from Westrail suggests that increased rail activity is unlikely to have adverse environmental implications. However Worsley acknowledges that further investigation of environmental impact may be warranted by Westrail and would co-operate as far as practicable with such an investigation.

The increased traffic resulting from the additional operational workforce will be insignificant considering the existing traffic volumes on Mornington and Coalfields Roads. The impact of construction workforce is also anticipated to be minimal.

The existing usage (most traffic is from sources other than the refinery) and accident rate on Mornington Road suggests that the future development of Mornington road needs to be seriously investigated. Worsley supports the formation of a State Government coordinated working party to address issues relating to the safety and development of Mornington and Coalfields Roads.

## Aboriginal Heritage

Some areas of potential archaeological significance under the Aboriginal Heritage Act have been detected in the project area. Safeguards will continue to be put into place to ensure that the expansion does not adversely affect these sites.

## Maintenance of Separation Distances

The future encroachment of residential land uses closer to mining, refinery and conveyor operations can give rise to a lower environmental amenity for those residents. Worsley will seek to prevent encroachment of sensitive development to its operation by:

- retaining Joint Venture ownership of land adjacent to project operations; and

- working with State and local authorities to ensure the development of regional and local town planning schemes takes into account future mining plans and refinery operations.

# 1. INTRODUCTION

## 1.1 BACKGROUND

The proponent, Worsley Alumina Pty Ltd (Worsley), is a management company for the Worsley Bauxite/Alumina Joint Venture.

The current participants in the Worsley Alumina Joint Venture are:

- Reynolds Australia Alumina Pty Ltd;
- Billiton Australia Pty Ltd;
- Kobe Alumina Associates (Australia) Pty Ltd; and
- Nissho Iwai Alumina Pty Ltd.

Since 1980, the proponent has managed the construction and operation of the existing alumina refinery near the Worsley siding and the associated bauxite mining, bauxite transport, alumina shipping and related facilities on behalf of the Joint Venturers. In addition, the proponent manages the mining and processing operations at the Boddington Gold Mine on behalf of another Joint Venture.

*The Alumina Refinery (Worsley) Agreement Act 1973* ratified the Agreement (Agreement) which provided the basis for the Worsley Project to proceed. This Agreement required the Joint Venturers to submit an Environmental Review and Management Program (ERMP) in order to begin project operations. The final ERMP for the Worsley Alumina (Reynolds, 1979) Project was submitted to the Government on October 1979. The Worsley Joint Venturers received environmental approval from the Government to proceed with the project in 1980.

The bauxite mine was commissioned in 1983 and the refinery in 1984 and production of alumina reached 1.0 million tonnes per annum (Mt/a) in 1985. Refinement of operating procedures increased production to 1.3 Mt/a and in December 1989 a "debottlenecking" of the project increased annual production to 1.5 million tonnes.

A proposal to expand alumina production to 2.25 Mt/a by a substantial upgrade of the refinery was referred to the Environmental Protection Authority (EPA) in August 1990 but did not proceed. In March 1992, an amendment to licences held by Worsley under Part V of the *Environmental Protection Act, 1986* was granted to reflect an alumina production level of 1.81 Mt/a.

## 1.2 SCOPE AND OBJECTIVES OF THE PROPOSAL

Worsley Alumina Pty Ltd (Worsley), acting on behalf of the Joint Venturers, propose to expand the refinery's production capacity from the current 1.75 to 3.5 Mt/a of alumina in two stages.

### *Stage 1*

An increase in production of alumina from 1.75 Mt/a to 2 Mt/a with minor modifications to refinery plant and the construction of Berth B loading facilities in the

Bunbury inner harbour. The Stage 1 development will involve an increase in mining of bauxite from 6.4 Mt/a to 7.3 Mt/a.

*Stage 2*

An increase in production of alumina production from 2.0 Mt/a to 3.5 Mt/a by a major upgrade of existing plant facilities and introduction of new process technology to increase efficiency. This stage will be implemented over a 2-3 year period following approval by the Joint Venturers.

Stage 1 and Stage 2 proposals were referred to the EPA in October 1995 in accordance with the provisions of the *Environmental Protection Act 1986*. The EPA determined that the level of assessment for the proposed Stage 2 expansion was a Consultative Environmental Review (CER). Stage 1 expansions are the subject of works approval applications to the Department of Environmental Protection.

The Worsley expansion project (Stage 2) consists of four components:

- mining up to 12.6 million dry tonnes of bauxite per year from existing mining leases near Boddington;
- transportation of mined bauxite by the existing 51 km overland conveyor from the mine to the refinery;
- processing of the additional bauxite by the Bayer process to produce alumina at the existing refinery 20 km north west of Collie; and
- transport of raw materials to the refinery and shipping of alumina product from the refinery through the Port of Bunbury.

This CER document deals with the Stage 2 expansion.

## 1.3 RELEVANT STATUTORY APPROVALS AND REQUIREMENTS

Worsley's operations are subject to the Agreement and require compliance with any requirement, in connection with protection of the environment, pursuant to any State legislation (including environmental protection requirements made by its agencies, statutory bodies or local government) that may be in force at any time. Recent amendments to the Agreement provide for the operation of the overland conveyor to be in accordance with a prescribed standard rather than be subject to the *Environmental Protection (Noise) Regulations.*

Under the Agreement the mining lease was granted to Worsley and operations are required to be carried out in accordance with the ERMP. A further environmental review is required under the Agreement when production of alumina exceeds 2.0 tonnes per annum.

The Agreement also requires Worsley to submit to the Minister for Resources Development for review, annual and triennial reports of its environmental management

including any monitoring or research. The Minister is advised on these reports by a committee of expert officers from relevant Government agencies (the Environmental Management Liaison Group - EMLG).

In addition to the Agreement the Worsley Project is subject to a number of Acts of Parliament and regulations at the State and Commonwealth level. A selection of the more relevant legislation is listed below:

- Aboriginal Heritage Act 1972.
- Australian Heritage Commission Act.
- Conservation and Land Management Act, 1984.
- Dangerous Goods Regulations.
- Endangered Species Protection Act 1992.
- Environmental Protection (Impact of Proposals) Act 1974.
- Environmental Protection Act 1986 as amended.
- Explosive and Dangerous Goods Act 1961.
- Hazardous and Toxic Substances Regulation.
- Health Act 1911 - 1979 and Regulations.
- Heritage of Western Australia Act 1990.
- Mining Act 1978 - 1987 and Regulations.
- Noise Abatement (Neighbourhood Annoyance) Regulations 1979.
- Occupational Health, Safety and Welfare Act 1984 - 1987.
- Rights in Water and Irrigation Act 1915.
- Soil and Land Conservation Act 1945 - 1982.
- Water Authority Act 1984.
- Waterways Commission Act 1976.
- Wildlife Conservation Act 1950 - 1980.

International agreements or treaties and national agreements and State policies that may directly or indirectly affect this project include:

- Montreal Protocol on Substances that deplete Ozone.
- Convention on Biodiversity.
- United Nations Framework Convention on Climate Change.
- National Greenhouse Response Strategy.
- National Strategy for Ecologically Sustainable Development.
- Revised Greenhouse Strategy for Western Australia.

The bauxite mine and refinery are subject to conditions of licences issued pursuant to Part V of the *Environmental Protection Act 1986*.

## 1.4 THE CER AND THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

The environmental impact assessment process for the CER is shown diagrammatically in Figure 1.

The scope of the CER addresses environmental issues associated with the expansion of alumina production on areas that would be directly or indirectly affected by the construction and operation of the expanded refinery and bauxite mining operations, and contains the environmental objectives to which the proposal will be managed.

The CER is intended to provide the EPA, public and Government agencies with an understanding of the proposal and the environmental strategies and commitments applied to address environmental issues of concern. The CER has been prepared in accordance with guidelines (Appendix 1) issued by the EPA which were subject to public review and Government agency input. Worsley conducted an extensive public consultation and scoping process undertaken to determine issues of concern to the local and broader communities.

The CER is subject to a six week public review period. At the end of this period points raised in written submissions from the public and Government agencies are collated, reviewed and transmitted by the Department of Environmental Protection to Worsley.

Worsley has an opportunity to respond to the points raised and provide a response to the EPA for its consideration. This response and points raised in submissions are attached to the EPA's report to the Minister for the Environment.

The Minister releases the EPA report and any person has the right to appeal within 14 days against the recommendations of that report. In the event of an appeal the Minister consults with other relevant Ministers before making any decision on the proposal.

## 1.5 PROJECT LOCATION

The Worsley Project lies in the Darling Plateau, which forms the south-western margin of the Great Plateau of Western Australia. The highest remnants of the plateau reach 400 m. Mount Saddleback lies within the mining lease to the south of Worsley's initial mining area within the Saddleback Timber Reserve area.

The central part of the Darling Plateau is dissected by a series of rivers and their tributaries, which originate from the east in the dry agricultural belt. The flow in most of these rivers is intermittent and the quality of water varies from fresh to saline.

Bauxite mining takes place near Boddington, mainly in State Timber Reserves on the eastern edge of the Darling Range in the northern jarrah forest. Crushed bauxite is transported 51 km by a two flight conveyor belt system to the refinery site near the Worsley siding, 20 km north-west of the town of Collie. The Worsley refinery lies within the Augustus River catchment in an area of historically logged jarrah forest. Raw materials and product are shipped through the port of Bunbury, 45 km to the south-west.

The project location is shown in Figure 2.

# 2. NEED FOR THE PROPOSAL

Implementation of the proposed Worsley expansion is based on perceived windows of opportunity in future world alumina markets. Expansion of the Worsley Project supports the company's world class standing and ensures that it remains a major alumina producer, local employer and export earner into the long term.

## 2.1 ECONOMIC BENEFITS

The proposed Refinery expansion would provide benefits to the State and Nation, including:

- an increased contribution towards the Nation's annual income through export sale of alumina;
- increased revenue to the State and Federal Government from taxes, levies, and royalties from the production of alumina and from taxation income from the Worsley Joint Venturers' profits; and
- increased direct and indirect employment opportunities (with subsequent financial flow-on effects) during the construction and operation phases of the expansion.

Of the $1.3 billion outlay during the initial construction phase of the Worsley Project, $1 billion (or 84%) was spent on Australian goods and services. Of the latter, approximately $888 million was spent in Western Australia, with the remainder ($120 million) being spent elsewhere in Australia. The proposed expansion would involve an anticipated expenditure of $670 million with proportionally similar benefits to both State and national economies.

## 2.2 LOCAL COMMUNITY BENEFITS

The construction and operation of the project expansion would provide significant and long-lasting benefits to the local communities, both socially and economically. These would include:

- employment opportunities for up to 600-700 people, during the construction phase and for up to an additional 150 people during the operation phase;
- increased demand for goods and services from local industries and businesses;
- increased population in local centres near the refinery and the mine site, thereby assisting State policies of regionalisation and increasing the revenue base for local authorities; and
- improved training of the local work force through on-the-job training and employer operated or sponsored training programs.

The majority of the workforce for the Worsley Alumina Project was initially recruited from local communities and the broader south-west region of Western Australia.

Wherever practical, a similar recruitment policy would be used to engage the additional workforce required for the refinery expansion. Recruitment of the workforce would continue to be totally non-discriminatory, with the objective of employing the most suited applicant available.

# 3. EXISTING BIOPHYSICAL ENVIRONMENT

A detailed description of the existing environment for the mine, conveyor, refinery and residue storage areas is given in Section 5 of the 1979 ERMP. Since 1979, baseline studies have produced additional information which is included in the following summary of the existing environment.

## 3.1 REGIONAL CLIMATE AND CHANGE

The project area has a Mediterranean climate with cool wet winters and hot dry summers. Approximately 80% of rain is received in the six month period May-October.

The weather is controlled largely by the movement of anticyclones west to east across the continent. In the winter this anticyclonic system moves to the north, bringing westerly winds to the south west of the state and maintaining a series of low pressure systems which also follow the west to east passage. The low pressure systems bring frontal rainfall to the south west of the state. During the summer the anticyclone belt moves south, producing dry easterly winds and keeps low pressure systems well to the south of the state.

Throughout the project area, mean maximum monthly temperatures range from 15°C in July to 33°C in February. The mean minimum monthly temperatures range from 6°C in July to 19°C in February.

Average annual rainfall for the Boddington bauxite mine is 740 mm, and 1300 mm at the refinery. Evaporation exceeds rainfall in the months between October and April throughout the project area.

The clearing of vegetation may result in changes to the microclimate in the areas affected. The clearing of 140 hectares of forest and the subsequent rehabilitation after mining for 30-35 years is anticipated to have no effect on the local climate (Rust-PPK, 1995).

As a consequence of global warming a number of climatic changes are anticipated (Mitchell *et al*, 1994).

Climate change scenario for the project area indicate an increase in air temperature of up to 1.5°C, and a change in rainfall pattern which could result in an increase of up to 20% in summer rainfall, and a ±10% change in winter rainfall throughout the project life. In addition, evaporation may increase by up to 6% and the magnitude and occurrence of extreme events may increase.

## 3.2 MINING AREA

Bauxite mining takes place on State and private land near Boddington on the eastern edge of the Darling Range. Most of the bauxite is under jarrah forest - with some small areas having been cleared for agriculture.

### 3.2.1 Bauxite Areas

The primary bauxite resource lies within the Agreement mining lease (ML 258SA) and nearby 1978 Mining Act mining leases (over private land) in the Lower Hotham Valley. The Primary Bauxite Area (PBA[1]) includes parts of three key areas of Crown land - the Saddleback, Marradong and Quindanning Timber Reserves. The northern part of the PBA is forested private land owned by the Boddington Gold Mine Joint Venturers and managed by Worsley. Additional areas of cleared and forested private land fall within the PBA around the Timber Reserves. The Project mining leases, the PBA and Crown and private land are shown in Figures 3 and 5

The top layer of bauxite (typically 40-60% of the full profile) is a strong, iron-cemented hardcap layer. The remaining bauxite is friable and earthy and is routinely referred to as B-zone bauxite. Figure 4 shows a typical laterite/bauxite cross-section.

The majority of the bauxite mined by Worsley has been derived from a suite of greenstone parent rocks. The greenstone derived bauxite is limited in distribution and is surrounded by bauxite laterite derived from a granite parent - the typical Darling Range bauxite.

### 3.2.2 Geomorphology and Soils

The general PBA landscape is undulating with uplands ranging from 280-400 m AHD and valley floors with gentle-to-steep slopes 50-100 m below this. Mt Saddleback (590 m), located in the southern part of the Saddleback Timber Reserve is the most prominent landscape feature in the area.

The landforms and soils in the region have been mapped and described by McArthur *et al* (1979). Five major landform units are recognised in the PBA. These are:

- Dwellingup landform: which consists of gently undulating laterised uplands with gravelly sands and sheets of duricrust. This is the most common landform in the PBA.

- Pindulup landform: which is associated with the Dwellingup landform and which comprises the valley slopes and broad valley floors commonly with duplex soils. This landform occurs in the Hotham north area.

- Coolakin landform: which consists of minor valleys (often bounded by the Dwellingup landform) which have been stripped of laterite. Soils are a gravelly, sandy duplex or sandy alluvium. This landform occurs as the drainage channels in the Saddleback Timber Reserve and Marradong Timber Reserve areas.

- Michibin landform: which consists of moderate to steep slopes between local divides with yellow duplex and red earth soils. This landform straddles the eroded landscape along the Hotham River.

[1] The PBA is a refinement of the Principal Mineralised Area (PMA) as referred to in the 1979 Project ERMP. The original PMA boundary is shown in Figure 3.

- Williams landform: which consists of the alluvial valley floors subtended by the slopes of the Michibin landform with yellow duplex soils. This landform occurs on the banks and flood plains of the Hotham River.

The bauxite resource is contained in the Dwellingup landform and slopes of the Pindulup landform.

### 3.2.3 Existing Land Uses

The three Timber Reserves have been harvested intermittently in the 1950s and 1960s for timber. The Marradong Timber Reserve was also harvested in the 1980s. Apiarists were active in the area during the 1950s and 1960s.

Much of the valley landforms on private land surrounding the Timber Reserves have been cleared for agriculture. Sheep grazing and mixed cropping are the most common land uses on these areas. Laterite-bauxite areas have generally not been cleared for agriculture due to the near-surface hardcap which precludes cultivation.

The (mostly forested) private land in the Hotham north area has been managed for saw log production and harvested for firewood and jarrah poles.

To date, all bauxite mining by Worsley has taken place in the Saddleback Timber Reserve area (Figure 7). The Boddington Gold Mine gold mining operation lies within the Hotham north area.

### 3.2.4 Flora

The PBA lies within the Darling Botanical District of the South Western Botanical Province (Beard, 1980). Vegetation units in two parts of the PBA have been comprehensively mapped and are shown in Figure 9. Vegetation mapping was undertaken and plant communities were compared to Havel (1975)

***Saddleback Timber Reserve***

Three baseline botanical surveys of this reserve (6,000 ha) have been carried out by Dames and Moore (Worsley, 1985), Martinek and Associates (1984) and Mattiske Consulting (1994a). These surveys recorded a total of 395 species (374 of which are native to the area) of vascular plants from 179 genera and 56 plant families.

Twelve vegetation units were delineated in this area (Martinek and Associates, 1984) and were grouped as follows:

- Six vegetation units are jarrah community types which comprise 94% of the Saddleback Timber Reserve vegetation. Jarrah community type vegetation occurs on the laterised uplands of the Dwellingup landform.

- Two vegetation units are wandoo communities which comprise 4% of the vegetation and occur on the lower valley slopes and valley floors of the Cookalin and Michibin landforms.

- Four vegetation units are heath communities covering 2% of the total area, are located on valley slopes, gullies and the summit of Mount Saddleback in the Dwellingup and Coolakin landforms.

***Marradong Timber Reserve***

Mattiske Consulting carried out a baseline botanical study of this reserve (1,950 ha) in 1989. A total of 290 vascular plant species, 161 genus and 57 plant families were recorded.

Nine vegetation units were delineated in the Marradong Timber Reserve area. Six of these vegetation units were classified as jarrah community types, two as wandoo community types and one as a heath community type. All of the vegetation units recorded in the this reserve area occur in the Saddleback Timber Reserve area.

***Other Areas***

The other key areas of the PBA - the Hotham north and Quindanning Timber Reserve areas - have been mapped during the System Six study.

A baseline botanical survey of the Hotham North area has been carried-out for Worsley and a report is currently in preparation.

***Rare and Endangered Flora***

No plant species which are listed in the Wildlife Conservation (Rare Flora) Notice 1995 under the *Wildlife Conservation Act, 1950*, Western Australia or under the *Commonwealth Endangered Species Protection Act* 1992 have been located in the Saddleback and Marradong Timber Reserve areas.

Fifteen priority species (as detailed in CALM's Rare and Priority Flora List, 1995; Appendix 2) have been recorded in surveys to date and are listed in Table 1. The local and regional distribution of these species is shown in Appendix 3.

### 3.2.5 Fauna

Baseline fauna investigations were carried out over the Saddleback area between 1980 - 1983 prior to the commencement of mining. Four fauna surveys have been undertaken in the area since 1984. The specific goals of these surveys have been to:

- monitor the impacts on the distribution and abundance of fauna in undisturbed jarrah forest adjacent to mining operations;

- monitor fauna recolonisation of rehabilitation; and

- identify fauna that may require special protection by the preservation of habitat areas and/or the provision of re-created habitats.

The baseline and ongoing fauna surveys are shown in Table 2.

**Table 1: Priority Flora Located in the Saddleback or Marradong Timber Reserves.**

| Species | Status |
|---|---|
| Acacia gemina ms | Priority 2 |
| Asteridia gracilis | Priority 1 |
| Calytrix simplex ssp. simplex | Priority 1 |
| Cryptandra polclada ssp. polyclada | Priority 3 |
| Dryandra subpinnatifida | Priority 3 |
| Eucalyptus aspersa | Priority 4 |
| Lasiopetalum cardiophyllum | Priority 2 |
| Senecio leucoglossus | Priority 4 |
| Spyridium oligocephalum | Priority 3 |
| Stenanthemum coronatum | Priority 3 |
| Stenanthemum intropubens ms | Priority 1 |
| Stenanthemum nanum | Priority 1 |
| Templetonia drummondii | Priority 4 |
| Tetratheca pilifera | Priority 3 |
| Verticordia heugelii var. decumbens | Priority 3 |

**Table 2: Baseline and Monitoring Fauna Surveys.**

| Title | Date | Reference |
|---|---|---|
| The Reptilian, Avian and Mammalian Fauna of Mount Saddleback | 1978 - 80 | Nichols and Nichols (1980) |
| Fauna Survey | 1980 - 81 | Dames and Moore (1981) |
| Flora and Fauna Studies Phase One | 1980 - 81 | Worsley Alumina (1981) |
| Flora and Fauna Studies Phase Two | 1982 - 83 | Worsley Alumina (1984) |
| Vertebrate Fauna Study Phase Three | 1983, 1987 | Ninox Wildlife Consulting (1990) |
| Assessment of Invertebrates | 1991 - 92 | Majer *et al* (1992) |
| Vertebrate Fauna Study Phase Three | 1991 - 92 | Ninox Wildlife Consulting (1992) |
| Vertebrate and Invertebrate Survey | 1994 - 95 | Ninox Wildlife Consulting (in prep) |

A list of all the fauna recorded in the original forested and rehabilitated areas is provided in Appendix 4. The following sections summarise what is known about fauna in the current mining area.

*Mammals*

A total of 26 mammal species have been recorded in the Saddleback Timber Reserve area, of which 19 are native and seven are introduced species. With the exception of the grey kangaroo (which is common in the area), the current population densities of native species are low but are the same as those determined by baseline surveys prior to mining.

The capture of eight brush-tailed possums, two brush-tailed phascogales and two mardos in the 1994-95 survey was significant because these mammals had not been recorded in previous surveys. Also significant was the capture of two brush-tailed possums in a two hectare rehabilitation trial plot established in 1980. One of these animals, a male, was recaptured in the area on several occasions over a period of eight months, indicating that the rehabilitated plot had been incorporated into its territory.

The chuditch is a gazetted rare species under the *Wildlife Conservation Act 1950* and the *Commonwealth Endangered Species Protection Act 1992*. Competition for food resources and predation by foxes is considered to be the primary cause for the widespread decline of the chuditch. High level predators are naturally common in disturbed ecosystems and baseline studies prior to mining indicated that the chuditch population density was already low in the Saddleback Timber Reserve area. Three chuditch were captured during the 1994-95 survey, indicating the population status of this animal had changed little since commencement of mining.

Two of the recorded mammals are listed on the 1994 CALM Reserve Species List. They are the brush-tailed phascogale and brush wallaby. Two phascogales were captured for the first time in 1994-95, both close to mined areas. Brush wallabies have been regularly recorded since baseline sampling commenced and have been observed using rehabilitated areas on several occasions. Both species are apparently secure in the Saddleback Timber Reserve area.

*Birds*

A total of 73 species of bird have been recorded in the Saddleback Timber Reserve area. The avifauna is typical of the wetter, forested south-west with an admixture of a few semi-arid zone species typical of the wheatbelt to the east.

Three of the recorded species are declared rare under the *Wildlife Conservation Act 1950*. They are the peregrine falcon, Carnaby's black-cockatoo and Baudin's black-cockatoo. The first is widespread throughout Australia and an uncommon and irregular visitor to the PBA. The two cockatoos are seasonally nomadic and are regularly recorded. Carnaby's black-cockatoo has been observed feeding in rehabilitated areas.

Two birds are listed on the 1994 CALM Reserve Species List. They are the square-tailed kite and the forest red-tailed black-cockatoo. Sightings of the square-tailed kite, a nest-predating species, have risen significantly since 1981 because of higher levels of bird breeding activity in rehabilitated areas compared to native forest. The forest red-tailed black-cockatoo has been regularly recorded in the saddleback Timber Reserve area since sampling commenced and appears secure.

Over 60% of all bird species found in the natural vegetation of the Saddleback area have been recorded in rehabilitated areas and some of these, primarily honeyeaters, reach significantly higher densities.

*Reptiles*

A total of 25 reptile species, 52% of which have been found in rehabilitated areas, have been identified in the Saddleback Timber Reserve area. The reptile community is typical of the drier, north-eastern Darling Range and lacks some species found in the wetter eastern sections of the region.

One reptile species declared rare under the *Wildlife Conservation Act 1950* - the carpet python - has been recorded on several occasions. While not captured in recent surveys, this secretive, high level predator has been opportunistically sighted confirming that it still inhabits the Saddleback Timber Reserve area in typically low densities.

*Frogs*

Nine frog species have been recorded and three of these have been captured in rehabilitated areas. No gazetted rare frogs occur, but one frog is listed on the 1994 CALM Reserve Species List; *Heleioporus barycragus*. This large frog is mainly restricted to wandoo woodland and patches of heath.

### 3.2.6 Water Resources

*Surface Waters*

The PBA is located mainly within the Hotham River catchment (Figure 3). The catchment incorporates a range of land uses including cropping, sheep and beef production, mining, silviculture and urban development.

The upper reaches of the Hotham River has tributaries in farmland in the Pingelly-Narrogin area well east of the catchment of the Darling Range. The river flows past the forested regions of the Hotham North, Marradong and Saddleback areas as a third-order river. The tributaries from those areas are mostly ephemeral.

The Hotham River flows to its confluence with the Williams River to form the Murray River which flows to the Peel Inlet at Mandurah.

Worsley recently commissioned Streamtec to sample surface waters at 52 sites throughout the Hotham River catchment. At each site measurements were made of salinity and estimates made of total water discharge. The sampling program is designed to continue with measurements being made on a quarterly basis. Results representative of the upper, middle and lower catchments from the first sampling program (September 1995) shown in Table 3.

**Table 3: Salinity Measurements in the Hotham River Catchment.**

| Catchment | Site | Stream Order | No of Sites | Salinity TSS mg/L | Discharge kL/day |
|---|---|---|---|---|---|
| Upper | Cuballing - Yornaning | 1 | 4 | 3,724 | 605 |
| Upper | Yornaning - Popanyinning | 1 - 2 | 3 | 5,396 | 1,969 |
| Upper | Popanyinning - Pingelly | 1 - 2 | 5 | 6,902 | 4,961 |
| Middle | Hotham (Pumphreys) | 2 | 1 | 5,616 | indeterminate |
| Middle | Crossman River | 2 | 1 | 4,856 | 21,600 |
| Middle | Hotham River (Dwarda) | 2 | 1 | 4,719 | 4,961 |
| Lower | Hotham (upstream of Saddleback) | 3 | 1 | 3,680 | 8 cumecs |
| Lower | Tributaries from Mt Saddleback | 1 | 4 | 121 | 86.4 |
| Lower | Murray River (confl. Hotham) | 3 - 4 | 1 | 3,124 | indeterminate |

The most saline streams in the catchment are in the upper reaches around Pingelly. The Hotham River at Pumphreys Bridge, upstream from the current mining area, has a high salinity level of 5,616 mg/L. As a result of the input from fresher tributaries, the Hotham River at Saddleback Timber Reserve has a reduced salinity of 3,680 mg/L. Tributaries from forested areas in the Saddleback Timber Reserve catchment are fresh, having a mean salinity of 121 mg/L.

In a catchment context, the Hotham River receives most of its salt as diffuse run-off from the farming regions east of the PBA. Run-off from the forested areas of Hotham North, Saddleback and Marradong Timber Reserve areas then dilutes the overall salinity before the Hotham River discharges into the Murray River. (Streamtec, 1995).

### *Groundwater*

Groundwater is currently abstracted from two aquifers in the Tunnell Road borefield to service mining operations.

Numerical modelling of the existing Tunnell Road catchment has indicated that under current climatic conditions, the catchment yield (from the shallow aquifer) averages 820 kL/day. The catchment yield from the fractured rock aquifer has yet to be determined (Mackie Martin PPK, 1994).

Monthly measurements of groundwater salinity in monitoring bores over the past 12 months have ranged from 160 to 391 mg/L which is classified as fresh.

### *Salt Storage In Soil*

A total of 98 salt holes have been drilled in the Saddleback Timber Reserve area. The average stored total soluble salts recorded in these holes is 1.13 kg/m$^3$ (range 0.05 to 4.7 kg/m$^3$). The recorded levels are 55% of the salt storage values considered to be typical of this region (Stokes, 1983). It is possible that the reduced level of salt storage has resulted from the different groundwater permeability characteristics of the

deep-seated clays derived from greenstone parent rocks compared to the more widely occurring granite derived clays.

### 3.2.7 Forest Disease

Jarrah dieback disease is associated with the introduced soil-borne fungus *Phytophthora cinnamomi* and is considered to be the major disease problem of Western Australia's native forests. The impact of *P. cinnamomi* is most significant on the wetter western edge of the northern jarrah forest with its incidence and associated impact becoming less significant toward the drier eastern edge of the jarrah forest. Low disease expression in inland areas is probably due to low rainfall (Shearer, 1994) and limited human activity (Shearer and Tippett, 1989).

Two *P. cinnamomi* infections covering approximately two hectares have occurred in the Saddleback Timber Reserve area. A third infection (less than 0.5 ha) has been located in the Marradong Timber Reserve at a disused gravel pit adjacent to the Pinjarra - Boddington road.

Armillaria disease is caused by the indigenous mushroom producing pathogen *Armillaria luteobublina*. The impact of Armillaria appears to be locally significant in the coastal dune vegetation and wandoo forest. Disease expression occurs less frequently in the jarrah forest (Shearer, 1994).

Several Armillaria infections covering approximately 10 ha are known to have occurred in the Saddleback Timber Reserve area.

Worsley's forest disease management strategy is outlined in section 5.2.3.

## 3.3 REFINERY AND OVERLAND CONVEYOR ENVIRONMENT

A comprehensive description of the existing environment of the refinery and overland conveyor areas was provided in the ERMP. It is not intended to repeat this information (apart from the descriptions provided below) but where appropriate any relevant information obtained since the approval of the ERMP will be provided in this section or the subsequent discussion of environmental impacts and management.

### 3.3.1 Overview of the Environment

The refinery and residue disposal areas are located 36 km from the coast in the Darling Scarp bounded to the west by the Swan Coastal Plain and to the east by the Collie Coal Basin. The refinery process area, residue disposal areas and dams straddle the broad dissected valleys of the tributaries of the Augustus River.

Vegetation communities change from east to west along the conveyor corridor and closely match rainfall distribution. In the eastern low rainfall region, low open forest of jarrah (*E. marginata*) and marri (*E. calophylla*) predominate with wandoo (*E. wandoo*) woodlands. Through the intermediate rainfall zone, a mixture of jarrah and marri woodland predominate. This woodland increases in height and density in the western high rainfall zone of the overland conveyor corridor and refinery area.

### 3.3.2 Existing Land Use

The conveyor passes through predominantly State forest except for farming areas along the Murray and Hotham Rivers. This land is primarily developed for pastures and cropping with some areas still forested.

The refinery is surrounded mainly by State forest, and to a lesser extent by private forest. The nearest farming areas are more than eight kilometres from the refinery.

State forest adjacent to the conveyor and refinery are managed by CALM for timber production, catchment protection, recreation and for the conservation of flora and fauna. The forests are also used for honey production.

### 3.3.3 Surface Water and Groundwater Resources

The refinery is located within the upper head waters of the Augustus/Brunswick River system. This water resource is important as both a natural aquatic ecosystem, and as a source of public water supply. A pipehead dam on the Brunswick River at Beela currently supplies potable water to the towns of Brunswick, Roelands and Burekup.

Ground water flow may occur in the following four soil horizons underlaying the refinery lease area:

1. The ferruginized zone overlaying the impermeable pallid zone which supports a seasonal perched watertable.

2. The thin ferruginous zone beneath the pallid zone.

3. The quartz residual sands (saprolite zone) resting on bedrock.

4. Sheet joints and fractures within the first few metres of bedrock.

Significant localised groundwater flow could occur vertically between zones along the shear zones of granites, contact zones of dolerite dykes, and pathways created by tree root systems.

Hydrogeological investigations prior to construction and refinery operations (GHD, 1980 and Layton Groundwater Consultants, 1981) detailed a site flow net and groundwater quality. These studies found that:

- Groundwater flow is directed from recharge areas higher in the landscape to the valleys of the Augustus River and its tributaries.

- There is no groundwater flow from the refinery lease area to the Wellington Dam catchment.

- Depth to watertable is 0-15 m and the watertable is at or near ground surface along the valley floors.

- Seasonal fluctuations of the watertable are up to 6 m with highest watertable levels in Spring and lowest levels occurring in Autumn.

- Groundwater is predominantly located in the saprolite zone.

- Transmissivities range from 1-5 $m^2$/day, specific yield from 0.02 to 0.03 in weathered rock and up to 0.05 in fractured rock and calculated velocities are in the range of 0.2-2 m/day.

- Salinity in the groundwater is generally less than 500 mg/L and seldom more than 1000 mg/L.

- Annual recharge from rainfall is thought to be of the order of 25 to 50 mm.

# 4. DESCRIPTION OF PROPOSAL

## 4.1 MINING

### 4.1.1 Bauxite Reserves

Exploration drilling of the core bauxite area near Boddington has been conducted on a 100 m or greater square grid. 25 000 exploration holes have been drilled around Boddington. The greenstone belt and immediately surrounding granite are the areas that have been intensively drilled and sufficient detail is known of those bauxite deposits to calculate mineable reserves. Figure 5 shows the Primary Bauxite Areas (PBA) which contains 390 million tonnes of mineable bauxite. About 80% of the bauxite is derived from greenstone parent rocks.

The areas included in the reserve calculation encompass all the identified bauxite prospective ground but exclude ground:

- where Worsley does not have mining title or a bauxite mining compensation agreement;
- which requires blasting of hardcap and which is within 500 m of a sealed public road, residence, church or gravesite or within 50 m of an unsealed public road;
- where ripping of hardcap is anticipated but is within 50 m of a sealed or unsealed public road or 100 m of a residence, church or gravesite; and
- within 800 m of the built-up area of the Boddington townsite.

The bauxite included in the reserve calculation is shown in Figure 5 .

Reserves within the PBA are expected to increase with more close-spaced drilling and establishment of mining compensation agreements with private land-owners.

There are identified bauxite prospective areas within mining lease ML 258SA to both the north and south of the PBA. Not all these areas have been drilled and in no case is drilling sufficiently intensive to allow a reserve to be calculated.

### 4.1.2 Long Term Mining Plan

Mineable bauxite reserves within the Saddleback Timber Reserve area stand at 160 million dry tonnes. This tonnage is planned to be hauled over an average distance of 5.2 km to the existing primary crusher in central part of the Reserve. The longest hauls being considered are up to nine kilometres. Mining in the Saddleback area may be extended to encompass relatively small bauxite deposits to the west.

Following the mining of all bauxite within the Saddleback Timber Reserve area, mining and primary crushing will be relocated to the Marradong Timber Reserve area. The conveyor system would be extended and primary crushed bauxite would be conveyed from this Reserve to the fixed secondary crusher in central Saddleback area.

Following the mining of all bauxite within the Marradong Timber Reserve area, mining and primary crushing would again relocate to the Hotham north area which is predominantly private land. The conveyor system would again be extended and primary crushed bauxite conveyed to central Saddleback Timber Reserve.

Figure 6 shows the indicative conveyor extension routes and primary crusher locations for mining in the Marradong Timber Reserve and Hotham north areas. The indicative route has not been finalised and appropriate access provisions would need to be agreed with private land-owners and Alcoa (if the final route was to go through its mining lease). Route selection and design specifications for the conveyor will be developed in consultation with relevant Government agencies to ensure that the environmental management plans are appropriate to the new installations. The Agreement requires that the conveyor routes be approved by the Minister for Resources Development.

### 4.1.3 Mining Operations

*Defining Orebodies*

Areas determined from exploration data to be prospective are sample drilled on a 50-70 m grid to provide data for operational mine planning up to 11 years ahead of mining. The data gained are used to identify the likely bauxite pods which are then drilled on a 25-35 m grid for detailed planning and mining control up to three years ahead of actual mining.

Sample drilling is by small, tractor-mounted 'Edson' vacuum drills, which can move through the forest with minimal disturbance and without any need to prepare access.

*Sequence of Mining*

Mining plans covering the ensuing 10 years of operations (10 Year Mining Plan) are prepared annually and discussed with CALM prior to their submission to the Minister for Resources Development. The 10 Year Mining Plan identifies orebodies and access routes expected to be cleared during the period of each plan.

At least 6 months prior to the intended clearing date for areas of Crown land, detailed clearing notices are submitted to CALM. CALM officers inspect the flagged area to determine forest salvage strategy and check for signs of dieback. CALM then licenses contractors for pre-clearing salvage of saw-logs (including low grade logs), firewood and more most recently, grass trees (*Xanthorrhea preissii*) and zamia palms (*Macrozamia riedlei*) (see section 5.2.4).

On private land, clearing notices required under the *Soil and Land Conservation Act 1945-1982* are lodged with the Department of Minerals and Energy. Dieback inspection is arranged by Worsley and salvage is then arranged by the land-owner.

Forest waste remaining after salvage is then heaped for burning during prescribed burning periods. Some larger logs, especially those which are hollow, are put aside for use as fauna habitat during rehabilitation.

The shallow (average 0.8 m) overburden is removed by scrapers. The topsoil (the first cut by the scrapers) is handled separately from the underlying gravel which can be up to two metres deep. The topsoil and gravel are separately placed back into areas prepared for rehabilitation (topsoil on top of gravel) or separately stockpiled where direct return is not practicable.

The overburden removal operation exposes the top layer of bauxite - the hardcap. Hardcap in greenstone areas and some granite areas requires drilling and blasting. In shallower granite areas large bulldozers can effectively rip. Large rocks remaining after hardcap breaking, which are too big to feed to the crusher (greater than 1.5 m diameter) are stockpiled at the loading areas or transported to a central area for secondary impact breaking.

In most areas the bauxite is excavated by horizontal benching using either a backhoe or a large front-end loader. In shallow, flat areas, the full profile is excavated and loaded in a single pass by front-end loader.

Bauxite is hauled up to six kilometres in 85 tonne capacity rear-dump trucks to either the primary crusher or the adjacent run-of-mine stockpile. Bauxite re-handled from the stockpile constitutes less than 10% of the total crusher feed.

### *Blending Bauxite*

The blending of bauxite with its inherently variable chemical and physical properties is a critical component of bauxite mining and mine planning. There are strict acceptance criteria for the alumina, reactive silica, free quartz and extractable oxalate and sulphate content of bauxite delivered to the refinery. In order to provide a range of bauxite grades to achieve the necessary blend, a number of ore pods, each with a number of faces, are kept open for mining at any time.

### *Crushing*

The original primary crusher is managed as a fixed installation. The primary crusher will accept rocks up to 1.5 m diameter and produce to less than 180 mm in diameter.

The crushed bauxite is then conveyed to the secondary crusher which reduces product size to less than 40 mm. This bauxite is stacked by fixed conveyor on a surgepile feeding the overland conveyor. Total surgepile capacity is 50,000 tonnes of which 3,000 - 7,000 t is reclaimable through the draw points without bulldozer assistance. Belt feeders deliver bauxite to an accelerator belt and thence to the overland conveyor at rates up to 2,300 t/hour.

### *Rehabilitation Earthworks*

The immediate post-mining landscape is rehabilitated to reflect the pre-mining landform. Details are given in section 5.2.2.

*Operating Structure*

Bauxite production is routinely scheduled for day and afternoon shift five days per week. Production and development work is often undertaken at weekends. Some development work is occasionally carried-out on night shift. Maintenance work is carried out around the clock five days per week and for an extended day shift at weekends. The mine works as an 'owner-operator' - with contractors being routinely or periodically engaged for specialist or peak-load work.

*Water Supply*

Groundwater meets 85% of the operation's water needs and is abstracted from the shallow and deep aquifers in the Tunnell Road borefield for dust-suppression on the haulroad network, in the fixed plant and as a potable water supply for the minesite.

The remaining 15% of the operation's water needs is currently sourced from a bore located near a haulroad on the eastern side of the current operation and a sump adjacent to the crushing plant.

### 4.1.4 Changes to Existing Operations

The expansion will result in an increased mining rate within areas previously approved for mining under the 1979 ERMP. Annual bauxite production will increase from 7.3 to 12.6 Mt/a and the area cleared for mining and mine development each year will increase from 80 to approximately 140 hectares.

In about 30-35 years, the bauxite reserves in the PBA will be fully mined. The Worsley refinery is expected to still be a cost-effective alumina production plant at that time. Further bauxite may be mined from the southern and northern parts of ML 258SA - the details of areas to be mined and the means of access would be planned and submitted to the State at least 10 years in advance of actual mining.

Mine production and development work will be undertaken over about 140 scheduled hours per week. The scheduled hours could fall within any part of the available 24 hours per day, 7 days per week. Operations would not, however, normally be continuous.

Water required for dust suppression would increase by about 50% to 300 ML/annum.

Annual rehabilitation will increase in proportion to the increase in clearing. The area 'open' may increase to provide operational flexibility to assist in mining noise management and increasing direct return of topsoil.

## 4.2 OVERLAND BAUXITE CONVEYOR

### 4.2.1 Conveyor Route

The 51 kilometre overland bauxite conveyor traverses the Darling Plateau from north east to south west passing from low to high rainfall zones. The conveyor is situated predominantly in State Forest except for a 8.5 km section passing through private property, including Joint Venture owned land.

### 4.2.2 Operation

At present the typical operating window of the conveyor is 6.00 am to 11.00 pm, usually five days per week. Routine maintenance of conveyor pulleys and cable and belt repairs is normally performed between 11.00 pm and 6.00 am or during the two days of the week when the conveyor is not operating. Major maintenance of drive facilities or complete cable or belt change overs is performed during longer shut down periods of the conveyor. As part of routine maintenance, vehicles continually patrol the conveyor at low speed.

In its current configuration the conveyor belt speed is 22 km/hr, and delivers 2,300 tonnes of bauxite per hour from the mine to the refinery stockpiles.

Project expansion will eventually require the conveyor to transport double the current quantity of bauxite from the mine to the refinery. This will be achieved principally by increasing conveyor operations to 140 hours per week with capacity for up to 24 hour run time per day, and by improving existing conveyor operating efficiency. Options of increasing conveyor belt speed above 22 km/hr and for increasing feed rates above 2,300 tonnes/hr are also being investigated.

## 4.3 REFINERY AND RESIDUE DISPOSAL AREAS

The refinery processes bauxite to extract alumina by using the Bayer process which can be divided into four basic steps;

- ***Digestion:*** bauxite is ground and digested in a hot caustic soda solution to dissolve the alumina.

- ***Separation:*** following digestion, insoluble bauxite residue is removed from the alumina rich solution by settling. The settled material is then washed and filtered to recover most of the caustic soda and dissolved alumina. The residue is then pumped to disposal areas.

- ***Precipitation:*** the clarified alumina rich solution is seeded and then cooled to precipitate alumina hydrate, which is separated by filtration and washed to remove impurities and recover the caustic solution.

- ***Calcination:*** washed and filtered hydrate is then calcined at high temperature with natural gas. This drives off chemically combined water and produces the final product, aluminium oxide (alumina).

Boilers and compressors in the power-house provide steam and compressed air for process operations, and electricity for the refinery, the overland bauxite conveyor, and the mine. The refinery obtains power from Western Power's 132kV distribution grid for peaking and emergency power requirements. At present the Worsley power house provides electricity to the Western Power grid.

Process flow and changes to refinery plant are shown in Figures 10 and 11.

The refinery operates on a continuous shift basis and will have a permanent workforce of up to 900 persons once the expansion project is complete.

### 4.3.1 Changes to Existing Operations

The Worsley Refinery consists of two process units, or trains. The proposed expansion will increase the efficiency of existing facilities and involve installing new process facilities and refitting existing equipment. Most of the production capacity increase will be provided by an increase in flow through the refinery by the construction of new plant. Plant expansion and additions are shown in Figure 10.

Major additions of plant are:

i) a process liquor purification facility;

ii) a fourth boiler (to be either coal or gas fired) in the powerhouse; and

iii) two gas fired calciners to give a total of six units.

The liquor purification facility represents the only addition to Bayer technology already employed at the refinery. The facility will reduce organic and inorganic impurities in process liquor resulting in an increased alumina yield from the refinery. The proposed plant facility consists of an evaporator and drying unit which produces a solid granular material. This material is fed into a gas fired rotary kiln which oxidises the organic impurities. During this process sodium sulphate will be produced and may be sold as a chemical feedstock. If a market cannot be found for this substance it will be disposed of in purpose built solar evaporation ponds (Figure 13).

The refinery expansion will result in an increased rate of deposition within the existing or currently approved bauxite residue disposal system. No other changes are planned in this area.

Other significant alteration or expansion of process facilities in the refinery are outlined below.

***Digestion***

The addition of a new coarse grinding facility incorporating crushers and the addition of two digester vessels and associated slurry heaters.

***Separation***

The addition of two super washers, one conventional washer and possibly a sands separation facility to increase recovery of caustic from the process.

***Heat Interchange***

The conversion of the existing heat interchange facility including the installation of a new heat interchange facility to reduce specific energy consumption.

*Precipitation*

A new simplified precipitation circuit, consisting of sufficient precipitators and agglomerators to provide 40 hour liquor retention time and associated heat interchange facility will be installed. In addition a new alumina hydrate seed thickener will be installed adjacent to the precipitation area.

*Calcination*

Two new calciners will be added to the existing four. These calciners will incorporate best practice technology to improve alumina quality and energy efficiency and reduce emissions.

### 4.3.2 Refinery Inputs and Outputs

The project expansion will alter the requirements for raw materials, water and energy; and also the production of wastes and emissions. Changes resulting from project expansion are shown in Table 4.

**Table 4: Changes in Raw Material Consumption and Atmospheric Emissions Resulting from Expansion**

| | At 2.0 Mt/a Production | At 3.5 Mt/a Production | Change (%) |
|---|---|---|---|
| Bauxite Mined (Mt/a dry) | 7.3 | 12.6 | 72.6 |
| Residue production (Mt/a wet) | 6.8 | 11.9 | 75.0 |
| **Consumption of raw materials**[2] | | | |
| Caustic soda | 1.0 | 1.5 | 50 |
| Lime | 1.0 | 1.3 | 30 |
| Coal | 1.0 | 1.5 | 50 |
| Natural gas | 1.0 | 1.9 | 90 |
| Equivalent energy | 1.0 | 1.6 | 60 |
| **Atmospheric Emissions** | | | |
| Sulphur dioxide (t/a) | 10,610 | 16,370 | 54.3 |
| Oxides of Nitrogen (t/a as $NO_2$) | 4,310 | 6,650 | 54.3 |
| Particulates (t/a) | 293 | 512 | 74.7 |
| Carbon dioxide (x1000 t/a) | 1,960 | 3,150 | 60.7 |

The expansion will result in greater energy and process efficiencies and decreased unit consumption rates of all raw materials except natural gas (Table 5). Consumption of natural gas overall will increase as a result of the addition of calciners and the liquor purification facility.

[2]Indexed to consumption prior to expansion.

Depending on fuel sources, atmospheric emissions will also increase. However, the specific unit rate of emission will decrease due to both increased production rate and an energy efficiency program designed to reduce coal and gas demand (Table 5).

**Table 5: Specific Rate of Consumption and Emissions per Unit of Alumina Production.**

| | At 2.0 Mt/a Production | At 3.5 Mt/a Production | % Change |
|---|---|---|---|
| **Consumption of raw materials**[3] | | | |
| Caustic soda | 1.0 | 0.8 | -20 |
| Lime | 1.0 | 0.8 | -20 |
| Coal | 1.0 | 0.85 | -15 |
| Natural gas | 1.0 | 1.08 | 8 |
| Equivalent energy | 1.0 | 0.9 | -10 |
| **Atmospheric Emissions** | | | |
| Sulphur dioxide (kg/t) | 5.49 | 4.68 | -14.8 |
| Oxides of Nitrogen (kg/t as $NO_2$) | 2.23 | 1.9 | -14.8 |
| Particulates (kg/t) | 0.15 | 0.15 | 0 |
| Carbon dioxide (x1000 t/t) | 1.01 | 0.9 | -11.0 |

Expansion of the refinery will result in increased water consumption (Figure 12) which may not be satisfied in the short term by the water from the refinery lease catchment. Options being considered to satisfy this supply shortfall include:

i) importing water from Wellington Dam ;

ii) utilising waste water from the planned Collie Power Station;

iii) construction of an alternative surface water storage area; and

iv) recovery of clean refinery condensate currently lost to evaporation or directed to the refinery catchment lake.

The large scale use of groundwater is not favoured because of low yield and the potential impacts on ground water hydrology which in turn may influence the integrity of residue disposal areas and the refinery catchment lake.

Consideration has also been given to obtaining water from the proposed Olive Hill dam on the Brunswick River. However this dam is not expected to be built until at least 2015 (WAWA, pers.comm) which is beyond the period required by Worsley.

[3] Indexed to consumption prior to expansion.

The final water supplement option will be subject to the provisions of the Environmental Protection Act.

### 4.3.3 Bauxite Residue Management

Filtered bauxite residue (60 - 62% solids) is pumped via pipeline from the refinery to bauxite residue disposal areas located to the north of the refinery process area. Production of bauxite residue will increase proportionally with refinery production increases associated with the expansion.

Under the original project approval, sites both to the north and south of the refinery process area were designated as part of the residue management system (Figure 13). No extension of these residue disposal areas will occur as a result of increasing refinery production. However, the expansion will necessitate the early commissioning of a residue disposal area, south of the refinery process area.

There are currently three operational residue disposal areas with a fourth being constructed and due to be commissioned in 1996. Potential leakage of contaminated water from the areas is prevented by a clay blanket seal at the base and two underdrainage systems consisting of slotted pipes and a gravel drainage layer located above and below the clay blanket.

The underdrainage system above the clay blanket collects seepage from the stored bauxite residue for reuse in the refinery process. The system below the clay blanket collects fresh water from underneath the residue disposal areas. The design of the underdrainage system enables monitoring of the residue areas and the separation of fresh and contaminated waters. A schematic cross section of residue disposal area and underdrainage systems is shown in Figure 14. The residue area containment system is subject to a comprehensive groundwater monitoring program.

Materials for construction of the residue disposal areas are sourced predominantly from within the refinery lease area. Clay materials are required on embankments and for the clay seal, and screened gravels are required for drainage of the residue. Clays are salvaged during residue area construction and are either stockpiled for future needs, or are directly used for construction of the residue impoundment. Gravels are screened on site and are obtained from laterite overburden and caprock.

Sands used for drainage areas in embankment construction are sourced off site from licensed borrow pits.

Future requirements for construction materials can be adequately met from current sources. Worsley is investigating options to separate sands from the bauxite residue and to transport gravel from the bauxite mine via the overland conveyor.

### 4.3.4 Transport of Raw Materials and Alumina

Currently 30 trains per week deliver coal, caustic and lime to the refinery, and transport alumina to the Port of Bunbury. A number of options for configuration of trains are being considered to accommodate the expansion. The most likely scenario

will see the length of some trains shortened to facilitate rapid turn-around at loading and unloading facilities. This may result in train movements increasing up to 65 per week.

Supplies of acids used in cleaning operations and flocculants are delivered by road transport. Deliveries by road will increase proportionally with the increase in production from four to eight trucks per week.

## 4.4 BUNBURY PORT FACILITIES

Alumina product and caustic soda required by the refinery are transported to and from the Port at Bunbury. Alumina and caustic soda are held in tanks and silos at the Worsley's Berth B lease site.

Loading and unloading of ships and trains is currently performed by arrangement with Alcoa through its Berth A facilities. All materials are handled in a sealed pipeline or in an enclosed conveyor transport system. The development of Berth B to accommodate the increased shipments of alumina will be in accordance with the environmental conditions set for the development of the Bunbury Inner Harbour.

The development of alumina loading facilities on Berth B is the subject of a works approval application with the Department of Environmental Protection.

# 5. ENVIRONMENTAL IMPACTS AND MANAGEMENT

## 5.1 ENVIRONMENTAL MANAGEMENT APPROACH

*Objective*

To achieve excellence in environmental management.

The mission of Worsley is to enhance its competitive position in the marketplace and to achieve growth and security through a commitment to sustained continual improvement in all areas of the organisation.

Importantly, one of Worsley's seven corporate critical success factors, designed to fulfil this mission, is to achieve excellence in environmental management. The assessment of excellence involves the ongoing practice of bench marking self performance over time and where appropriate against external standards and organisations.

Worsley carries out its activities in accordance with best practice environmental management where best practice implies the use of the best practicable equipment, process or systems and techniques.

Supporting the pursuit of environmental excellence is the Worsley policy that, as far as is practicable, every employee is responsible for and involved in environmental management. This approach ensures that environmental issues are integrated, routine components of project planning and operations. It has proven effective by enabling proactive environmental planning and optimum utilisation of resources for environmental planning activities.

In accordance with this corporate approach, the role of Worsley's environmental personnel is to coordinate the implementation and continuous improvement of Worsley's environmental management programs by:

- educating employees as to their environmental responsibilities and empowering them, through the provision of specialist advice and services, to meet environmental commitments; and

- monitoring, auditing and reporting environmental performance to ensure compliance with statutory requirements, due diligence in environmental management and corporate environmental objectives.

### 5.1.1 Environmental Management Systems

To facilitate planning, implementation and reporting of environmental management, Worsley has implemented an environmental management system which comprises five broad (and overlapping) programs. These programs are education, services, environmental studies, monitoring and reporting. Implementation of these programs is facilitated through Worsley's developing environmental compliance system.

### *Environmental Education*

Effective workforce education is important to the success of Worsley's corporate philosophy of devolved responsibility for environmental management. The objectives of Worsley's environmental education program are:

(i) to communicate to the workforce the basis (legal, social, corporate) for Worsley's commitment to high quality and continuous improvement of environmental management;

(ii) to foster a positive and supportive environmental ethic in the workforce;

(iii) to provide the information needed by individuals to understand their environmental responsibilities; and

(iv) to explain the services and support provided by the Worsley environmental team.

### *Environmental Services*

Specialist environmental services provided by the environmental team enable employees to take responsibility for environmental management at Worsley.

The objectives of Worsley's environmental service program are to:

(i) provide employees with specialist advice and services to enable them to meet their environmental commitments; and

(ii) ensure environmental planning and management activities occur in a co-ordinated manner throughout the operation and over the life of the project.

### *Environmental Studies and Investigations*

The primary purpose of Worsley's environmental studies program is to conduct research and assimilate information necessary to successfully implement and continuously improve Worsley's environmental management programs. Specific research objectives are dynamic in that they must be able to respond to changes in operational procedures, Government requirements and public perceptions and expectations.

Typical study objectives in this program include:

(i) the development of rehabilitation prescriptions and ultimately a closure strategy for bauxite residue areas;

(ii) the improvement of existing prescriptions and ultimately the preparation of completion criteria for mine pit rehabilitation consistent with the long term rehabilitation objectives determined in consultation with the Government;

(iii) optimisation of the use of water resources such as the bauxite mine Tunnell Road aquifers and the refinery freshwater lake;

(iv) the investigation of recalcitrant plant species in mine rehabilitation;

(v) improvement in identification and treatment techniques for forest disease such as jarrah dieback;

(vi) the development of rehabilitation prescriptions for agricultural properties associated with bauxite mining;

(vii) the development of techniques and the investigation of control equipment to further mitigate noise emissions associated with the operation;

(viii) provide data to demonstrate the feasibility of proposed rehabilitation strategies; and

(ix) the development of a project close-out strategy.

***Environmental Monitoring and Auditing***

The primary purpose of Worsley's extensive environmental monitoring is to provide feedback on performance to enable continuous improvement of Worsley's environmental management programs. Coupled with existing monitoring, Worsley is embarking upon a program of environmental process audits with a view to improving environmental performance and ascertaining compliance with environmental management procedures.

Current activities of this program aim to:

(i) monitor the establishment and development of vegetation structure, flora diversity, and the fauna recolonisation of mine pit rehabilitation;

(ii) demonstrate compliance with statutory controls and corporate environmental objectives;

(iii) evaluate the accuracy of environmental impact assessment predictions and the effectiveness of Worsley's environmental management program; and

(iv) prepare environmental audit plans for the bauxite mine and the refinery.

***Environmental Reporting***

Worsley is required to periodically submit reports to Government. The objectives of Worsley's environmental reporting program are:

(i) to comply with statutory reporting requirements;

(ii) to maintain a high standard of reporting addressing the needs of the receiver; and

(iii) to provide feedback to the workforce regarding Worsley's environmental activities and performance.

*Environmental Compliance System*

In order to audit the effectiveness of Worsley's environmental programs, Worsley has devised and is in the process of implementing an environmental compliance system based heavily on workforce involvement, particularly in the development of procedures. For ease of auditing and ongoing management, the Worsley environmental compliance system is comprised of four tiers, these being:

i. All statutory environmental requirements specific to the Worsley Project.

ii. Environmental Acts and Regulations relevant to the Worsley Project.

iii. Regulatory Agencies environmental guide-lines relevant to the Worsley Project.

iv. Industry best practice (as defined in section 5.1).

The major components of the system are:

- identification and documentation of each environmental requirement or commitment;
- an understanding of the basis of the environmental requirement or commitment;
- the appointment of a designate responsible for ensuring compliance with the environmental requirement or commitment;
- identification of Worsley's policy on environmental management;
- development and periodic update of Worsley's procedures for compliance with the environmental requirement or commitment;
- completion of compliance statement by the designate to confirm compliance with an environmental requirement or commitment; and
- company-wide publication of a summary of compliance performance against the environmental requirement or commitment as a means of ongoing workforce environmental awareness.

The process of internal auditing and exercise of due diligence provides accurate feedback on the implementation and an opportunity for continual improvement of Worsley's environmental management program, consistent with ensuring best practicable environmental protection.

### 5.1.2 Government Liaison

Worsley's environmental planning, monitoring, auditing and investigative activities are formulated and reported to the State in accordance with Worsley's commitments. In both meeting statutory requirements and in further developing Worsley's processes of

self regulation in environmental performance, these activities are facilitated through consultation with the various regulatory agencies.

The Worsley Environmental Management Liaison Group (EMLG) was established in order to fulfil Agreement objectives to advise on mining and environmental matters and is central to the process of Government liaison. The group undertakes annual inspections of the environmental aspects of the Worsley Project and provides advice to the Minister for Resources Development. The EMLG is chaired by the Department of Resources Development (DRD) in its capacity as administrator of the Agreement Act on behalf of the Minister for Resources Development.

The liaison group is comprised of expert representatives from:

- Department of Environmental Protection (DEP)
- Department of Conservation and Land Management (CALM)
- Water Authority of Western Australia (WAWA)
- Department of Minerals & Energy (DOME)
- Department of Resources Development (DRD)

Worsley support the co-ordination of statutory reporting and life-of-project environmental considerations, such as completion criteria and closure strategies, through a single multi-disciplinary group representing relevant Government agencies. This approach facilitates both comprehensive evaluation of significant environmental matters by a Government expert panel and a timely, consolidated response to company environmental initiatives.

Worsley support the further development and formalisation of the existing arrangements for the above environmental management liaison group to review, audit and advise Government on environmental requirements of the project together with the development of life-of-project environmental strategies where appropriate.

### 5.1.3 Community Liaison

Worsley conducts annual briefings and meetings with local land owners situated in the vicinity of the mining operations, to discuss the rolling ten year mining plans and related environmental matters. Given the relative isolation of the refinery from nearest neighbours (8 km), community liaison at the Worsley site has historically been more intermittent and issue driven. Periodic briefing representations are undertaken by Worsley at the local government level.

Worsley's community response procedures ensure that any issues or complaints raised by members of the local community can be received twenty four hours a day and responded to in a timely and effective manner.

***Environmental Management Commitments***

1. Formalise Worsley's interaction with the existing Government expert panel (Environmental Management Liaison Group).

2. Prepare environmental audit plans for bauxite mine and refinery.

3. Undertake regular internal audits of key processes.

4. Prepare and submit annual environmental management reports to the State.

## 5.2 MINING OPERATIONS

### 5.2.1 Conservation of Flora and Fauna

*Objectives*

To ensure that the biodiversity and sustainability of eastern Darling Range forest ecosystems are maintained from adverse impacts of Worsley's bauxite mining activities.

To ensure that rare and endangered flora and fauna within the mining area are protected.

***Existing Environmental Conditions, Commitments and Policies***

In 88% of the public submissions to the draft ERMP (DCE, 1979) the most widely expressed concern relating to mining was the preservation of the jarrah forest ecosystem. There were concerns that mining would threaten existing conservation areas and preclude the establishment of further conservation and recreation reserves.

The lack of detailed information on the local flora and fauna was also an issue raised in public submissions.

The preservation and conservation of flora and fauna is covered by three Western Australian statutes; the *Wildlife Conservation Act, 1950*; the *Conservation and Land Management Act, 1984* and the *Environmental Protection Act, 1986*. The enacting of the Commonwealth *Endangered Species Protection Act, 1992* enabled involvement by the Federal Government in the protection of endangered or vulnerable species. Australia is a party to the international Convention on Biodiversity.

Worsley has implemented the flora and fauna conservation program that it committed to in the 1979 ERMP. The key elements of that program are:

- minimising the operating area of the mine;
- undertaking flora and fauna surveys prior to mining; and
- flora protection research.

***Potential Significance of Impact***

The clearing of native vegetation prior to mining has the potential to impact on the jarrah forest ecosystem and impair the long term viability of populations of species known to be rare and endangered or geographically restricted.

Based on current proven bauxite reserves, up to 65% of the forest area in the PBA will be left uncleared. On the basis of current knowledge of the bauxite resource a similar proportion of native vegetation will remain undisturbed in the Marradong and Hotham north areas. A higher proportion of vegetation (approximately 80%) in the Quindanning Timber Reserve area will remain undisturbed.

The rate of clearing in State forest will increase areas from a present rate of 70 ha per annum to an estimated 140 ha per annum in the Saddleback and Marradong areas and Hotham north areas. Approximately 95% of the Hotham North area is privately owned land.

No plant species listed under the Western Australian *Wildlife Conservation Act 1950*, or the Commonwealth *Endangered Species Protection Act, 1992* have been located in the Saddleback and Marradong areas.

Fifteen flora species from CALM's Declared Rare and Priority Flora List have been located in the Saddleback and Marradong areas and are listed in Table 1.

The Tunnell Road heathland is considered to have conservation values of both local and regional significance because of its biodiversity, habitat value and size (Mattiske Consulting, 1995a Ninox Wildlife Consulting, 1995a).

Fauna of interest include:

- the chuditch, which is listed under the Commonwealth *Endangered Species Protection Act, 1992* occurs throughout the jarrah forest and is known to occur in low densities in the PBA;

- the peregrine falcon, Carnaby's black-cockatoo and Baudin's black-cockatoo which are declared rare under the *Wildlife and Conservation Act (1950)* and have been recorded in the Saddleback area; and

- the carpet python which is listed as rare under the *Wildlife and Conservation Act (1950)* and has been recorded on several occasions in the PBA.

***Flora and Fauna Conservation Strategy***

Worsley's flora and fauna conservation strategy has been developed and implemented in consultation with CALM and consists of:

- baseline monitoring of an area prior to mining;

- educating the workforce on the importance of strategies to protect of flora and fauna;

- not adversely affecting significant plant communities and designated priority flora in mining areas;

- not adversely affecting rare and endangered fauna; and

- rehabilitation of the forest ecosystem (see section 5.2.2)

On the basis of the current understanding of flora and fauna in the PBA and the continued updating of the flora and fauna conservation strategy, the clearing of native vegetation for mining will not significantly affect biodiversity or threaten rare flora and fauna.

*Educating the Workforce*

The effectiveness of a flora and fauna conservation strategy is dependent on the degree of involvement of the workforce. To help facilitate this process the following procedures are in place:

- all new employees are inducted in the flora and fauna protection program as part of the company's formal induction process; and

- a fauna watch program has been implemented and is currently undertaken by employees by recording sightings of fauna, including the chuditch. This supplements information gained from biological monitoring programs and provides employees with a sense of involvement in fauna conservation.

*Protection of Significant Plant Communities and Priority Flora in Saddleback Area*

The following areas are considered to have conservation values that have not been found in other areas to date. Mining in these areas will not occur until an assessment is made in consultation with CALM as to the conservation significance of these areas in a local and regional context.

- heathland community 22H Hu which is 7 ha in area and occurs on the upper slopes in the Saddleback Timber Reserve;

- heathland community 24H Cq which is 10 ha in area and occurs at the summit of Mount Saddleback;

- sheoak (*Allocasuarina huegeliana*) community 24A Ah which is 1.3 ha in area and abuts community 24H Cq; and

- the Tunnell Road heathland which comprises 80% of the heathland community type 23H Dc.

On the basis of what is known to date the heathland communities 22H Hu and 24H Cq and sheoak community 21A Ah do not occur over bauxite areas (see Figure 9).

Fifteen plant species designated in CALM's Declared Rare and Priority Flora List September 1995 have been located in the Saddleback and Marradong areas. The abundance and geographical distribution of these species is given in Table 1.

Monitoring programs currently indicate that all of the 15 species can be considered to be adequately protected from the impacts of mining on the basis of the following:

- twelve of the priority species were located in heathland community 24H Cq and the Tunnell Rd heathland ( 80% of 23H Dc) which have been deferred from mining;
- three of the priority species have been located in Wandoo Woodland, of which an estimated 90% is likely to remain undisturbed by mining;
- recruitment (recolonisation) of seven of the 15 priority species have so far been recorded in mine rehabilitation areas; and
- seven of the 15 priority species known to occur in jarrah type vegetation have been recorded in other forested areas outside the Saddleback and Marradong Timber Reserves.

*Protection of Rare and Endangered Fauna*

All of the fauna located in the Saddleback area requiring statutory or special protection have a geographical home range that extends well beyond the PBA and eastern Darling Range forest which indicates that no species is threatened by bauxite mining and associated activities.

Fauna protection strategies include:

- retention of approximately 65% of the native vegetation in the mining area;
- minimisation of the mining operations area;
- revegetation of eastern Darling Range forest mined areas with locally sourced eastern Darling Range type vegetation;
- re-creation of fauna habitats (see section 5.2.2);
- collaborative feral animal control programs (see section 5.2.4); and
- Investigating options for wildlife corridors.

***Flora and Fauna Conservation Commitments***

5. Undertake baseline flora and fauna surveys prior to mining in new areas.
6. Regularly monitor the abundance and distribution of flora and fauna in forest adjacent to mined areas.
7. Defer mining in areas of potentially high conservation values in the Primary Bauxite Area (PBA) until it can be shown that the biodiversity and sustainability of the ecosystem of the eastern Darling Range will not be adversely affected.

8. Encourage recruitment of rare or priority flora and rare and endangered fauna into rehabilitated areas.

9. Investigate the creation of a wildlife corridor linking the Saddleback and George forest blocks.

10. Implement a feral animal and weed control program.

11. Support recalcitrant plant species research applicable to Worsley Alumina bauxite mining operations.

### 5.2.2 Rehabilitation

*Objectives*

To ensure that rehabilitation of mined areas in the State Forest is timely, sustainable and meets completion criteria agreed by the State.

To ensure that rehabilitation of mined areas on private property leaves the land in an environmentally stable and sustainable condition and meets the requirements of the private property owner.

***Existing Environmental Conditions and Commitments***

Half of the public submissions to the draft ERMP (DCE, 1979) considered Worsley's rehabilitation objectives for mined land were unjustifiably optimistic given that rehabilitation had not being attempted in lower rainfall areas of the eastern Darling Range.

Worsley has implemented a rehabilitation program that it committed to in the 1979 ERMP, in consultation with the former Forest Department (now CALM). The key elements of that program were:

- shaping the mined land to facilitate surface drainage;
- replacement of topsoil from a stockpile or by direct stripping of the soil surface during overburden removal;
- ripping the pit floor; and
- liaison with the former Forest Department in determining the appropriate tree species for rehabilitation by establishing a two hectare trial.

The proposed program was further developed on the basis of trial programs and in 1984, Worsley Alumina's bauxite mine-pit rehabilitation prescription was developed in consultation with CALM. The prescription is evolving and is constantly reviewed with CALM in response to information from monitoring and research programs.

***Potential Significance of Impact***

The potential significance of clearing native vegetation prior to mining has been addressed in Section 5.2.1 Rehabilitation of previously forested land with the pre-existing flora species is considered desirable to:

- facilitate the development of eastern Darling Range forest ecosystems; and
- mitigate other potential impacts such as rising groundwater levels and the mobilisation of stored salt in the soil profile.

The existing land use objectives of the Saddleback, Marradong and Quindanning Timber Reserves areas include conservation, recreation, timber production and beekeeping.

Disturbance to agricultural land requires a rehabilitation prescription that is designed to restore the pre-existing productivity qualities and mitigates other potential impacts such as rising groundwater levels, mobilisation of stored salt, and wind and water erosion that could affect the land capability of the rehabilitated area.

***Rehabilitation Strategies in State Forest***

Worsley has implemented a program of rehabilitation in accordance with a rehabilitation prescription which has been developed in consultation with CALM. The broad objective of rehabilitation is to regenerate a forest ecosystem with flora and fauna characteristics comparable to the eastern Darling Range forest that existed prior to mining.

Specific goals include the maintenance of recreation, conservation, landscape and hydrology forest values.

A total of 862 ha has been cleared for mining operations of which 66% (568 ha) is being rehabilitated.

The following methods are currently used for rehabilitation;

*Rehabilitation Earthworks*

Mined areas are:

- landscaped and shaped to reflect pre-mining landforms;
- deep ripped to 1.5 m at 1.0 m intervals along land contours to promote root system development and enhance water in-filtration;
- re-spread with gravel and topsoil; and
- scarified to a depth of 40 cm at 1.0 m spacing along land contours to minimise erosion scouring and provide textured soil conditions for seed germination.

*Revegetation*

The revegetation methods and species have changed since 1986 in response to monitoring and research programs.

Table 6 demonstrates the change from establishing a eucalypt forest ecosystems in 1986 to an eastern Darling Range forest in 1995.

Current revegetation strategies aim to establish a vegetation type that reflects the pre-mining vegetation. Most of the mined area (approximately 95%) was originally jarrah-type vegetation and is revegetated with this type of vegetation. Areas that were previously wandoo or heath type vegetation are also revegetated with wandoo and heath-type vegetation respectively.

Seedlings of wandoo (*E. wandoo*) and blackbutt (*E. patens*) may be planted in areas considered to be potential water gaining sites. In addition heathland-type vegetation areas (up to one hectare) are established to promote biodiversity and encourage fauna recolonisation.

Between March and July of each year mine-pit areas become progressively available for revegetation following rehabilitation earth-works. Immediately following scarification, areas are broadcast with native seed collected from up to 90 species of trees, legumes, understorey and groundcover plants from local flora provenances. Seed mixes representing jarrah, wandoo or heath type vegetation are broadcast at a rate of 1.0 - 1.2 kg/ha.

**Table 6: Comparison of Revegetation Techniques from 1986 and 1995.**

| Process | 1986 | 1995 |
|---|---|---|
| Topsoil Replacement | Direct return of topsoil to 10 - 20% of mined area | Targets developed to achieve up to 35% direct return of topsoil |
| Tree Species | 18% eastern states eucalypts, 50% powderbark, wandoo 18%, jarrah 14% and other WA eucalypts | 66% jarrah, 24% sheoak, 10% marri |
| Tree Establishment | Hand planting at 500 stems per hectare | 75% hand planting at 500 stems per hectare.<br>25% direct seeding of 600 - 1,000 trees per hectare |
| Understorey | Up to 50 species native to the area | Up to 90 species native to the area and local provenance specific |
| Understorey Application | Seed broadcast in mid - June to July | Seed broadcast immediately following scarification, from March to July |

Currently in 25% of rehabilitation areas, no tree seedlings are planted. Seed from tree species is applied at a rate which aims to establish 600 - 1,000 trees per hectare, nine months after seeding.

In 75% of the rehabilitation areas tree seedlings are planted at a rate of 500 stems per hectare. Each seedling is fertilised with a 200 g diammonium phosphate tablet, placed 20 - 30 cm upslope from the root systems. The area is then fertilised by the aerial application of superphosphate (containing trace elements copper, molybdenum and zinc) at a rate of 450 kg/ha, one month after the completion of planting.

Other strategies designed to enhance the species richness and biodiversity of rehabilitation are described below.

*Direct return of topsoil*

Fresh topsoil is considered an important native seed source for species from which viable seed is difficult to obtain. A total of 161 species recorded in rehabilitated areas were not seeded and either germinated from the replaced topsoil or were recruited from the adjacent forest vegetation.

The current target is to spread fresh topsoil or topsoil that has been stockpiled for less than six months in dry conditions over a minimum 35% of the rehabilitated mine pit area.

*Minimising the Operations Area*

The clearing of vegetation for mining operations is restricted to bauxite areas and other areas required to service the operation. This results in irregularly shaped pits which have a higher ratio between the forest/mine-pit boundary and the area of a mine-pit compared to areas that were cleared in "blocks". The higher the ratio the more successful the recruitment of flora from adjoining areas of native vegetation.

*Recalcitrant Species*

Worsley is currently trialling the propagation of selected plant species by transplanting cuttings grown under nursery conditions in collaboration with Alcoa of Australia. This technique will be used where species have either not been recorded in rehabilitation areas or are well below baseline population densities. Species from the genera *Hibbertia, Lomandra, Leschanaultia, Xanthorrhoea and Macrozamia* have been included in the trial.

*Fauna Habitats*

In consultation with CALM, fauna habitats constructed from rocks, hollow logs and soil are currently being trialled in rehabilitation areas. It is anticipated that these habitats will help facilitate fauna recolonisation of mine pit rehabilitation areas.

***Flora Monitoring and Past Performance***

Two methods of monitoring the flora in rehabilitated mine-pits established in consultation with CALM are currently used at the bauxite mine to monitor the establishment and development of native vegetation.

1. Establishment of flora nine months after tree planting and seeding, the tree seedling survival and number of plants per square metre are recorded for each mine pit area.

2. Development of flora permanent 20 x 20 $m^2$ monitoring plots are established in mine-pit areas greater than three hectares and measurements carried out include species richness and abundance and plant cover. Assessments are currently undertaken at 1, 4, 7 and 10 years after commencement of rehabilitation

*Establishment Criteria*

Success criteria have been developed in consultation with CALM to measure initial revegetation performance. These criteria include:

- 80% survival of tree seedlings, nine months after planting;
- establishment of one native plant per square metre, nine months after seed broadcasting; and
- establishment of 600 stems per hectare for the area direct seeded with tree species nine months after broadcast seeding;

Monitoring of rehabilitated areas has shown that:

- tree seedling survival rates nine months after planting have consistently ranged from 85-95%;
- understorey establishment nine months after seeding has ranged from 1.8-9.8 native plants per square metre;
- for areas rehabilitated in 1994, by direct seeding of tree species, 650 stems per hectare were recorded nine months after seeding;
- of the 374 native species that have been recorded in the Saddleback Timber Reserve area during baseline studies, 282 species have so far been recorded in rehabilitation areas, of which 121 species were seeded and 161 species were non-seeded (ie germinated from topsoil or opportunistically invaded from adjacent forest);
- of the 72 most commonly recorded species from baseline studies, 61 species have been recorded in rehabilitation; and
- species richness measurements per 80 $m^2$ in native vegetation from baseline studies range from 41 to 57 in jarrah plant communities. In a recent monitoring program, species richness measurements of 35 and 42 were recorded for one and four year rehabilitation.

### *Fauna Monitoring and Past Performance*

Worsley monitors fauna recolonisation of mine pit rehabilitation areas. The most recent fauna survey (Ninox 1995b) has shown that vertebrate fauna is beginning to recolonise mine pit areas that were revegetated between seven and nine years ago. Table 7 compares the number of species recorded in uncleared native vegetation with areas rehabilitated.

**Table 7: Number of Species of Vertebrate Fauna Recorded in Native Vegetation and Rehabilitation.**

| Fauna | No of Species Recorded in Undisturbed Areas | No of Species Recorded in Rehabilitation Areas |
|---|---|---|
| Mammals | 26 | 13 |
| Birds | 73 | 44 |
| Reptiles | 25 | 13 |
| Frogs | 9 | 3 |

The recolonisation rate currently stands at 53% of all known native vertebrates in the Saddleback area and is expected to rise as rehabilitation areas mature (Ninox, 1995b).

### *Rehabilitation Strategies on Agricultural Land*

Under the Agreement, the company is required to enter into a Consent, Compensation, and Restoration Agreement with the owner to conduct bauxite mining and related operations on private land. Under the Agreement Worsley and the owner are required to discuss and agree on terms of the restoration program including:

(1) the purpose for which the owner's land will be used at the termination of the restoration program; and

(2) the types and quantities of vegetation that will be planted on the owner's land.

Worsley began mining on private land not owned by the Worsley Joint Venturers adjacent and east of the Saddleback Timber Reserve in 1993. A rehabilitation prescription has been developed with the owner in consultation with the Department of Agriculture. A catchment management approach has been adopted for the rehabilitation of previously cleared mined land. The approach has a long term objective to restore a sustainable agricultural system.

Other rehabilitation goals include the maintenance of landscape, hydrology, conservation and agricultural productivity values.

*Rehabilitation Earthworks*

The methods described for forested areas are applicable to mined private land in areas that are to be revegetated with Eastern Darling Range type vegetation. Where pasture is to be re-established the soil surface is smoothed and lightly scarified to facilitate seeding by farm machinery.

*Revegetation*

The revegetation strategy incorporates the following principles:

- re-establishment of eastern jarrah forest type vegetation in pre-existing forested areas;
- establishment of high yielding pasture on pre-existing pastoral areas; and
- strategically placed alleys of trees to combat groundwater level rise and erosion.

***Visual Impact Management***

Mining will have a temporary effect on landscape qualities in the PBA. Some of the bauxite reserves are located on the slopes of Mount Saddleback which is recognised as having the most significant visual landscape qualities in the PBA.

The undulating landscape in the area essentially restricts visibility of Mount Saddleback to the local area. Background (6.5 - 16 km) and occasional middleground (0.5 - 6.5 km) views of Mount Saddleback do occur from the local road network. Mount Saddleback is visible from a ridge on the Albany Highway immediately north of Williams at a distance of approximately 35 km.

The clearing of vegetation prior to mining on the slopes of Mount Saddleback will result in a temporary alteration to the landscape. In particular the structure, colour and texture characteristics of the landscape will change during the period of clearing, mining and rehabilitation. These visual characteristics will be restored in the long term as the rehabilitation matures.

The strategy to minimise visual impacts includes:

- identify areas (in consultation with CALM) that have significant visual landscape qualities;
- minimise the time between clearing and mining and rehabilitation of an area that has visual landscape qualities; and
- where practicable use vegetation to screen areas of significant visual impact.

*Mine Rehabilitation Commitments*

12. Trial re-creation of fauna habitats in rehabilitation areas.

13. Monitor flora establishment and development by measurement of species richness, abundance and tree growth rates.

14. Work with CALM to further develop rehabilitation enhancement techniques (including direct seeding).

15. Revegetate forested areas with seed collected from local provenance areas.

16. Minimise the time between clearing for mining and rehabilitation of areas that have high visual aesthetic values.

17. Use vegetation screening in areas of significant visual impact where practicable.

### 5.2.3 Forest Disease Management

*Objective*

To minimise the risk of bauxite mining activities introducing or spreading jarrah dieback or other forest diseases into areas of State and private forest.

*Existing Environmental Conditions*

In public submissions to the draft ERMP (DCE, 1979), the accelerated spread of dieback through the jarrah forest was identified as a source of community concern.

Worsley has implemented the forest hygiene program that it committed to in the ERMP. The key elements of that program are:

- minimising the operating area of the mine;
- educating the workforce about forest hygiene;
- facilitating dieback research;
- monitoring the extent of dieback in the Saddleback Timber Reserve in conjunction with CALM (former Forest Department); and
- developing hygiene procedures for exploration and other activities operating in State Forest and Timber Reserves.

*Potential Significance of Impact*

Bauxite mining and associated activities such as forest clearing and exploration have the potential to introduce and spread jarrah dieback. The fungus, *Phytophthora cinnamomi* which causes jarrah dieback can be spread through the movement of soil on vehicles and equipment and by surface water runoff.

An estimated 14.2% of the jarrah forest is affected by *P. cinnamomi* (Davison and Shearer, 1989) resulting in the death of jarrah trees and many understorey species. The greatest incidence of *P. cinnamomi* occurs in the northern jarrah forest on the western edge of the Darling Scarp. However, a significant decrease in expression is observed towards the drier eastern edge of the jarrah forest. The low disease expression in inland areas is thought to be attributed to:

- low rainfall which is an unfavourable condition for the survival and sporulation of this introduced, moisture-dependent micro-organism (Shearer, 1994): and
- limited human activity in comparison with western jarrah forest (Shearer and Tippett, 1989).

The potential impact of *Armillaria luteobublina* is most significant on coastal dune vegetation and wandoo forest where dead and dying host plants occur frequently in patches. In the jarrah forest, infections occur infrequently and affect individual plants or small patches of vegetation (Shearer, 1994). *A. luteobublina* can be spread by movement of infected root material and by airborne spores.

The hot, dry summers, seasonal rainfall patterns and well drained soils in the mining area appears likely to limit the impact of dieback in forested areas. The expression of *A. luteobublina* appears to be host-related and is more significant in areas of wandoo forest east of the mining area (R & J Dieback, pers. comm.).

***Forest Disease Management Strategy***

Worsley's forest disease management strategy has been developed and implemented in consultation with CALM. The key components of the strategy are:

- detection of forest disease prior to mining;
- mine planning and operations;
- prevention of forest disease introduction and spread;
- workforce education;
- rehabilitation of diseased areas where required; and
- supporting research relevant to improving forest disease management.

*Detection of Forest Disease Prior to Mining*

Prior to the clearing of any vegetation for mining, the area is mapped (according to procedures agreed with CALM) for the presence of dieback and other forest diseases by detailed visual inspection along traverse lines 25 m apart. In the event that the expression of dieback or some other forest disease is identified or where the risk of dieback is considered high, these sites are isolated from routine clearing operations and managed separately.

*Mine Planning and Operations*

The mining plan is developed in accordance with forest hygiene procedures and is based on a disease risk minimisation objective.

Mining operations include the following disease risk minimisation measures:

- as far as practicable haulroads are low in the landscape;
- containment of drainage from haulroads by the construction of drainage sumps designed to cope with at least a one in fifty year storm event;
- water used for dust suppression measures on the haulroad network is dosed with fungicide (hypochlorite solution); and
- after clearing but prior to overburden removal a perimeter drain is constructed around operational areas.

*Prevention of Forest Disease Introduction and Spread*

Minimising the risk of introduction of forest disease to the mining area is facilitated through the application of forest hygiene procedures which restrict access to the mining area and require vehicles and equipment to be hygienically clean prior to gaining access.

Minimising the risk of the spread of jarrah dieback and other forest diseases within the mining area is achieved in part through the classification of the mining area into Disease Free Areas, Restricted Areas, Unrestricted Areas, Safe Roads and Unsafe Roads and through the application of disease prevention measures which have been developed in consultation with CALM. The classification of areas is based on standard operating practices and the results of routine dieback detection surveys.

Details of the current forest hygiene procedures used to minimise the risk of both the spread of existing expressions of disease and the introduction of new infections are given in Appendix 5

*Workforce Education about Forest Disease*

The effectiveness of forest hygiene management at Worsley is dependent on employee commitment to the program. To facilitate this process at the bauxite mine, the following workforce education procedures are followed:

- new employees are inducted in the forest hygiene management program as part of the company's formal induction process; and
- forest hygiene management workshops are held annually for all employees working on the minesite.

*Rehabilitation of Diseased Areas*

In small areas of jarrah dieback infection, vegetation that has been affected by jarrah dieback is treated with a dilute phosphoric acid solution (Fos-jet 200) by an experienced plant pathologist. This involves the inoculation of jarrah trees by injection and the spraying of the understorey by conventional means. Time effectiveness of these measures is being evaluated.

In conjunction with CALM and the Boddington Shire, Worsley has recently contributed to the rehabilitation of a jarrah dieback infected area (less than 0.5 ha) in the Marradong Timber Reserve on a disused gravel pit adjacent to the Pinjarra-Boddington road. The area is not associated with mining activities. The rehabilitation involved delineation of dieback affected areas, site preparation, forest track closure and re-routing, broadcasting wandoo seed, sowing of understorey species and fertilising.

*Research*

Worsley is currently co-sponsoring research aimed at improving and expediting the techniques available for the identification of *P. cinnamomi.* This research project is coordinated by the Minerals and Energy Research Institute of WA.

Future research sponsorship by Worsley will aim to include support for the continual improvement of dieback management strategies.

***Monitoring and Past Performance***

The rate and extent of the spread of the only two *P. cinnamomi* infections identified in the Saddleback Timber Reserve since project commencement, is monitored in accordance with procedures developed in consultation with CALM.

If further *P. cinnamomi* infections are identified, the area affected will be recorded, monitored, and reported regularly to the appropriate Government agencies.

Since 1979, no new dieback infections have been recorded on the Saddleback Timber Reserve where mining has occurred. In 1992 a dieback infection (less than one hectare) was discovered on Worsley Joint Venture owned land which was considered to pre-date mining but had not been identified prior to the commencement of mining activities.

Monitoring of infections over the past two years has revealed the absence of an "active dieback front" with plant deaths near the infection being sporadic and more likely caused by drought. There is no evidence from monitoring that mining has caused any significant spread of jarrah dieback disease in the mining area.

Several *A. luteobublina* infections in addition to those identified prior to 1979, have been recorded in the current mining area. These infections are localised and affect a small proportion (approximately 10 ha) of the current mining area. Movement of a disease front has not been observed. The capacity of this fungus to spread by air-borne spores suggests the continued potential for the future expression of infections unrelated to mining activities.

To date Worsley's forest disease management strategy has been effective in minimising the risk of the spread and introduction of forest diseases in association with its mining activities.

***Forest Disease Management Commitments***

18. Maintain a dieback disease management strategy and hygiene procedures.

19. Support research relevant to forest disease management and Worsley's mining operations.

20. Rehabilitate forest project areas affected by jarrah dieback.

21. Monitor the rate and spread of forest disease infections in the mining area.

### 5.2.4 Integration with CALM Forest Management

***Objective***

To minimise the impacts of bauxite mining activities on other users of the State Forest, by integrating as far as practicable Worsley's activities with CALM's forest management.

***Existing Environmental Conditions and Commitments***

In accordance with of the *Conservation and Land Management Act (1984)* the management of the Saddleback, Marradong and Quindanning Timber Reserves is based on the Forest Management Plan 1994-2003 (CALM, 1994). Multiple use management principles are applicable to these areas and include bauxite mining, recreation, timber production and bee keeping uses.

The co-ordination of bauxite mining and forest management planning has been developed by Worsley in conjunction with CALM and is subject to annual review by ELMG through Worsley's 10 Year Mining Plan and Environmental Management Report both of which are submitted to the Government.

Forest management activities that require an integrated management approach include:

- fire protection;
- forest salvage;
- feral animal control; and
- relinquishment by Worsley of parts of ML 258SA for incorporation into conservation reserves by CALM.

*Fire Protection*

Worsley and CALM have developed a fire protection strategy through the Worsley - CALM Hazard Reduction Burning and Wild-fire Suppression Agreement. The agreement includes the planning and implementation of prescribed burning on a area rotation basis. Provision is also made for emergency procedures in the event of a wildfire.

*Forest salvage*

Prior to mining the area is cleared of vegetation. Under current arrangements the following forest products are salvaged prior to clearing:

- jarrah and sheoak sawlogs
- jarrah poles
- firewood
- grass trees and zamia palms
- hollow logs and forest debris for fauna habitats

The remaining forest material is heaped into piles and burnt. Worsley is placing increased emphasis on returning as much forest debris as possible to the rehabilitation areas.

*Feral Animal Control*

The chuditch occurs in low densities in the PBA (section 5.1). Competition for food resources and predation by foxes is thought to have contributed to the contraction of its home range and population decline. Research by CALM scientists has shown that control of the fox can lead to significant increases of certain animals, such as the chuditch, in forest areas (CALM, 1994). Baseline surveys in the Saddleback area have recently being carried out to ascertain the distribution and abundance of the chuditch. The results from these surveys will be used to monitor the chuditch population in response to fox control programs that may be implemented in the future.

*Relinquishment of Areas from Worsley's Mining Lease*

Since the granting of Mining Lease ML 258SA in August 1983, the Worsley Alumina Joint Venturers have progressively relinquished parts of the lease. Relinquishments have been for conservation purposes or after confirmation that areas were not prospective for bauxite. The remaining lease area now is broadly prospective for bauxite. The total area initially excluded or subsequently relinquished from the lease for conservation is 551 $km^2$.

Figure 3 shows ML 258SA and all conservation based relinquishments to date as well as areas excluded from the lease at the time of grant.

The evaluation of the remaining parts of ML 258SA proposed by CALM for conservation reservation (shown in Figure 3) is an on-going process. Worsley expects to work closely with CALM to assess areas of forest within ML 258SA during the Regional Forest Agreement processes established by the State and Federal Governments. Worsley expects that a balanced outcome, meeting conservation and economic development objectives, can be achieved.

Any exploration drilling to be undertaken in areas remote from the current mining operations is specifically discussed with CALM prior to field-work being carried out.

***Integration with CALM Forest Management Commitments***

23. Work with CALM to implement the integrated fire management plan with particular emphasis on protection of rehabilitation.

24. Work with CALM to maximise the salvage of forest products prior to clearing.

25. Co-operate with the Agriculture Department, CALM and the local community to develop a fox control strategy in the Primary Bauxite Area.

26. Work with the State to identify areas of ML 258SA outside the PBA with potentially high conservation value that can be precluded from mining without significant impact on the life of the project.

### 5.2.5 Water Resource Protection

***Objective***

To ensure that the environmental values of water resources are maintained from adverse impacts of bauxite mining activities.

***Existing Environmental Conditions and Commitments***

Nearly 70% of the public submissions to the draft ERMP (DCE, 1979) expressed concern that the clearing of the forest would increase salinity in nearby streams. It was felt that if rehabilitation of mined areas was not successful, then salinity increases could adversely affect the fresher subcatchments of the Murray River.

Worsley has implemented a water resource management program that is designed to protect the ground and surface water resources in and around the mine. The key elements of this program are:

- minimising the operating area of mine;
- containing stormwater runoff from operations area;
- provision of settling ponds to avoid dispersal of turbid flow;
- rehabilitation of mined areas with deep-rooted vegetation; and

- collection of solid and liquid wastes with appropriate onsite treatment and offsite disposal (discussed in detail in section 5.2.9)

***Potential Significance of Impact***

The clearing of native vegetation prior to bauxite mining together with groundwater abstraction from the Tunnell Road heathland area has the potential to alter the hydrology in and around the mining area. The significance of this impact is affected by the rate of clearing and groundwater abstraction and the time between clearing and rehabilitation.

***Monitoring and Past Performance***

The following routine measurements are carried out as part of the water resources management program:

- monthly conductivity and pH measurements in surface waters (creeks, rivers and farm dams) in the Saddleback Timber Reserve area;

- monthly conductivity, pH and groundwater level measurements in monitoring bores located in the Tunnell Road sub-catchment and other sub-catchments where groundwater could be used to meet future water supply requirements; and

- regular flora monitoring of the Tunnell Road heathland.

*Hotham River Catchment*

The results of the spring monitoring (Sept 17-20 1995) program, involving 52 sites in the Hotham River catchment, show that elevated salt levels in the Hotham River result from diffuse run-off from farming regions north east of the PBA around Pingelly. The salinity levels in the river decrease as it flows past the forested catchments of the Hotham North, Marradong and Saddleback areas where the river is diluted by the input of fresher tributaries (see section 3.2.6) (Streamtec, 1995).

*Hotham River Catchment: Saddleback Area*

The monitoring of surface waters in the Saddleback area has been carried out by Worsley on a monthly basis since 1978. The total soluble salt (TSS) concentrations upstream and downstream from mining activity on the Hotham River are shown in Figure 15. Salinity levels in the River from both monitoring locations during 1995 are comparable to the pre-mining levels in 1983.

Monitoring to date shows no significant impact of Worsley's mining operations on salinity levels in the Hotham River.

*Tunnell Road Borefield Groundwater Levels*

The borefield currently meets 85% of the minesite's annual water requirements (200 ML/annum). Groundwater levels in four monitoring bores, rainfall and borefield

abstraction rates have been monitored since 1991 and the results are shown in Figure 16.

An apparent downward trend in groundwater levels commencing in 1994 and ending in the first half of 1995 corresponds to a period of increased groundwater abstraction and well below average rainfall. In this period the rainfall was 235 mm less than that the average rainfall normally anticipated. Groundwater levels recovered in the period May - October 1995, when average rainfall was experienced.

Reductions to the groundwater levels under the Tunnell Road heathland may be expected to decline for short periods but the levels begin to recover when normal rainfall resumes. This is also reflected in other sub-catchments.

*Tunnell Road Borefield Vegetation*

The potential impact of groundwater abstraction on the heathland vegetation was examined by Mattiske (Mattiske, 1994b) during a systematic flora survey which compared the species richness and abundance of the area with pre-mining baseline studies (Worsley, 1985).

This investigation noted significant changes in the floristic composition, but suggested these changes may be due to variable climatic factors and the dynamic nature of heathland communities. Plant stress observed was attributed to inter-plant competition, senescence and natural moisture variations and could not be attributed to fluctuating groundwater levels.

Mackie-Martin - PPK (Mackie-Martin, 1994) also investigated the potential impacts of groundwater abstraction on the heathland by analysing monitoring data and undertaking, field investigations and water catchment modelling. This study concluded that:

- it was unlikely that any of the heath species were drawing from the groundwater system during the summer months. The depth to groundwater ranges from 3-12 m during the summer months. Root system development of most heathland species is confined to the surface 30 cm of soil; and

- studies of heathland communities indicate that heath species are capable of storing water during wet winter months for utilisation in the dry summer months.

***Mount Saddleback Paired Catchment Study***

The effects of mining on catchment hydrology and salinity are currently been studied by the Water Authority of Western Australia (WAWA), as part of an established program in the high, intermediate and low rainfall zones of the Darling Range. A paired catchment approach was utilised for this study in which two adjacent catchments (Hunt A and B) were maintained for a calibration period (12 years) prior to mining one catchment. The Hunt A and B catchments are 2.07 $km^2$ and 1.81 $km^2$ in area respectively and are located in a low rainfall area (Figure 7). Mining of the Hunt B catchment begun in 1986, by 1990 10% of this catchment had been rehabilitated.

Gauging stations and a network of 41 piezometers in both catchments were established in 1975 to monitor streamflow, water quality and groundwater levels.

During 1992, the monitoring data was reviewed by WAWA and the following observations were noted:

- groundwater levels rose in the order of 8 metres over 6 years to 1992 in the mined catchment.

- the variability of groundwater levels over the catchment created uncertainty in attributing groundwater level rise; and

- stream chlorinity averaged 72 mg/L in 1990 and 1991, whereas between 1975 and 1977, an average chlorinity of 475 mg/L was recorded (Goodman, 1992). This decrease was thought to be a result of below average rainfall.

***Water Resource Management Strategy***

Worsley's water resource management strategy has been developed, implemented and modified to ensure the clearing of vegetation and groundwater abstraction do not adversely affect the environmental values of water resources or significantly impair the health of overlying vegetation.

The strategy consists of more efficient use of water, increased use of captured stormwater and alternative sources.

Water demand at the mine is expected to increase by 50%, from 200 - 300 ML/annum. Increased haul road distances and longer operating hours require a greater amount of water to suppress dust emissions. Night shift road watering requires proportionally less water compared to daytime operations due to lower evaporation rates. Water supply is currently being sourced from the:

- shallow aquifer (50% of water needs) of the Tunnell Road borefield;

- deep fractured rock aquifer (35% of water needs) of the Tunnell Road borefield; and

- a single shallow bore in the eastern Saddleback area and a surface run-off collection sump adjacent to the crushing plant in central Saddleback Timber Reserve.

To meet future increased water demand the emphasis will be to seek supply from other sources in order not to increase draw on the shallow Tunnell Road aquifer. The following options are being investigated to reduce water consumption and reduce the draw upon the shallow aquifer:

- further development of the deep rock aquifer in the Tunnell Road borefield;

- the development of an alternative borefield; and

- the trialling of environmentally approved wetting agents to improve the effectiveness of dust suppression.

On the basis of the results of existing monitoring programs and the continued implementation of revegetation and water management strategies, forest clearing and groundwater abstraction for the expansion will not significantly adversely affect the environmental values of the local water resources and the Tunnell Road heathland.

***Water Resource Protection Commitments***

26. Investigative alternative sources of water supply.

27. Investigate means of increasing the effective use of water for dust suppression.

28. Monitor regularly the conductivity in surface waters in areas adjacent to mining activities, groundwater levels in harvested borefields and the health of the Tunnell Road heathland.

29. Investigate stored salt in the soil profile in the Marradong and Hotham North areas prior to mining.

30. Defer mining within the Hunt A Catchment until after 1998.

### 5.2.6 Noise And Blast Vibration Management

***Objective***

To comply with statutory requirements so that the amenity of nearby residence is protected from noise impacts resulting from bauxite mining activities.

***Existing Conditions and Commitments***

Noise emissions are currently regulated under the *Environmental Protection Act 1986* using the *Noise Abatement (Neighbourhood Annoyance) Regulations 1979*. The Environmental Protection (Noise) Regulations are currently under development and draft six (as amended) of these proposed regulations has been adopted as the standard for noise management at the mine. The draft regulations specify the following general noise limits at noise sensitive premises:

- 45 dB(A) (from 7 am to 7 pm) Monday - Saturday;
- 40 dB(A) (from 7 pm to 10 pm) Monday - Saturday;
- 40 dB(A) (from 7 am to 10 pm) Sunday, Public Holidays and;
- 35 dB(A) (from 10 pm to 7 am)

The general noise level is best characterised as 'L10' - the measured noise level which is only exceeded for 10% of the measurement time. Higher noise levels are permitted

where land within 450 metres of noise sensitive premises is zoned for industrial (eg mining) or commercial (eg independent farming) operations. The noise limits reduce if the generated noise has some specified negative characteristics (eg tonality). Under the draft Regulations, noise levels for short periods may be higher than the general noise limit.

Airblast overpressure emissions from the minesite have been regulated under Part V licence conditions since 1989, with annual reports submitted to the Department of Environmental Protection.

Worsley's noise management strategy to which it committed to in the ERMP includes:

- fitting appropriate sound power suppression to mining equipment; and
- investigating airblast overpressure and operational sound emissions to ensure compliance with regulations.

***Potential Significance of Impact***

Mining operations within the PBA will be conducted proximity to some residences, which will be exposed to mining equipment sound and airblast overpressure. Mining operations will be extended and will be routinely scheduled during the 10.00 pm to 7.00 am (night shift) period.

Most of the bauxite within the PBA will require drilling and blasting prior to mining. Blasting is required two to three days per week. It is expected that at expanded production rates blasting activities will be required five days per week.

***Noise Management Strategy***

Worsley's current noise management strategy includes:

- predicting mining sound levels;
- adjusting mining operations, fitting noise suppression devices, acquiring quieter equipment; and
- monitoring performance.

*Prediction of Mining Noise*

To assist in predicting and managing mining sound levels, Worsley uses the computer software, Environmental Noise Model (ENM). This model allows the input of detailed operational aspects such as equipment sound power, topography, terrain and meteorological data to generate sound level contours surrounding the operation or detailed sound level information at a selected location. The output from ENM is cross-referenced with Worsley's weather database to predict the probable occurrence of a particular level of mining sound at a nominated receival point. Herring Storer Acoustics have been appointed to assist Worsley in the validation of the model by

assisting in conducting field measurements of mining sound levels and the review of the output of ENM.

Appendix 6 details the sound power level information used for modelling mining sound levels. This data represents the sound power level of our current mining equipment in its current configuration.

Three typical operating situations have been modelled:

- A long haul operation comprising northern and south western Saddleback Timber Reserve mining pods, crushing plant and several haul trucks.
- Retracted operation utilising "core" mining pods located closer to the central crushing plant and utilising fewer trucks over a shorter haul distance.
- Fallback operation of two loaders reclaiming from the run of mine stockpile and feeding the crushing plant.

The predicted L10 sound level at each of 10 key residences under a variety of wind speed and direction conditions for these operations are presented in Appendix 6. Detailed L10 contour plots for wind in the predominant night time direction are shown in Figures 17, 18 and 19 in Appendix 6.

The following are important factors to be taken into account when predicting mining equipment sound levels in receptor areas:

- Weather - Wind speed and direction is the most significant variable in noise management- other than the location of noise sources relative to receival points. Other weather related variables (eg vertical temperature gradient or cloud cover) have limited impact on modelling results.

  The wind speed and direction data from the bauxite mine's meteorological station has been assessed over a 12 month period (1 September 1994 - 31 August 1995). This data is used in the model to determine the critical wind speed at the nearest residence for each of the eight monitoring sectors (See Appendix 6).

  The predominant wind direction at night is from the south east sector (34% of the time) Wind roses which demonstrate the seasonal wind direction and wind speed for three periods: 7 am to 7 pm, 7pm to 10 pm, and 10 pm to 7 am over the 12 month period are shown in Appendix 6.

  Background Sound Levels - Background sound levels have been recorded at a number of residences under a variety of wind speeds. It was found that the L 10 sound level was above 35 dB(A) at wind speeds above 4m/sec. A critical wind speed of 4m/sec is used for noise modelling purposes. At wind speeds above 4m/sec mining sound is likely to be masked by background sound.

- Sound characteristics - The noise limits at noise sensitive premises may be reduced if one or more of the following sound characteristics is present:

* tonal;
* modulation; or
* impulsive.

Worsley in association with Herring Storer Acoustics has found that tonal or impulsive characteristics can be detected in mining sound levels in some instances. Further work is required to determine the level that these sound level characteristics occur and what adjustment, if required needs to be made to the noise limit at affected residences.

- Model Verification - Worsley has monitored mining sound levels within the mining area and at nearby residences and compared these results with the predicted sound levels of the model output. It was found that where mining sound levels dominated background sound levels, the model was consistently predicting above the L1 level. At locations where background sound levels dominated the model prediction was well below the recorded levels.

  Monitoring has shown that there is generally a 5 dB(A) difference between the recorded L1 and L10 sound levels when mining sound levels dominate. The model's L1 output contours have been adjusted to produce L10 contours (Figures 17,18 and 19).

*Modification of Mining Operations*

Under typical mining operations during the night shift period the model predicts that sound level output will be within compliance conditions for 64% of the time.

By modifying the mining operation and retracting to the core mining area, the model has shown that compliance conditions can be achieved during all day shifts and during 87% of the time during night shift.

Further modification to the mining operation by limiting operations to reclaiming from stockpiles near the crusher plant enable compliance conditions to be met 96% of the time during night shift.

Sound power reduction initiatives on the current mining equipment and plant will enable the mining operation to meet compliance conditions more than 96% of the time during night shift. Where required mining operations can be contracted further to meet noise limits.

An outcome of the strategy will be an increase in open mining areas to create alternative mining areas in each wind sector.

*Equipment Sound Power Reduction*

Mining equipment sound power and the attenuation of sound levels with distance is dependent upon the sound power generated at different frequencies. Worsley conducts tests to determine the sound power levels of key mining equipment on a routine basis.

External consultants such as Herring Storer are used to benchmark Worsley's equipment and validate results.

Worsley has been reducing the sound power from various items of mining equipment and plant where testing has indicated that levels are higher than desirable.

The work conducted to date and the most promising of the planned work for the future is listed in Table 8.

Mining equipment and plant component manufacturers have made major advances in reducing sound power levels. Newer equipment and plant components are almost universally significantly quieter than older equipment - even if the older equipment has been re-worked to reduce sound power. Worsley expects that much of it's current mining equipment (now about 14 years old) and some further plant components will be replaced prior to or coincident with the need to routinely mine on night shift.

*Airblast Overpressure Management*

Blast design and management to limit airblast overpressure emissions has been a key operational requirement. The charge weight per delay, initiation management and blast design are tailored for each individual blast to comply with Worsley's internal airblast overpressure target of less than 110 dB (lin) peak.

Weather conditions are also critical and blasting is scheduled to take into account prevailing and likely weather conditions at the time of the blast.

The airblast overpressure from each blast is monitored at the most sensitive premises, as determined by distance, topography, meteorological factors and local experience.

Worsley is currently reviewing with ICI Australia the potential for developing computer software that can be used for predicting airblast overpressure.

### *Monitoring and Past Performance*

Worsley has not conducted routine monitoring of mining sound levels. On occasions when complaints are received, monitoring is conducted to determine the source of the noise and the appropriate action to be taken. Worsley has received eight complaints relating to mining noise since July 1989. Whenever complaints are recorded, they are investigated and appropriate corrective action taken.

Comments from neighbours and from our Worsley personnel, often identify the reversing alarms on mining vehicles as the most intrusive. The reversing alarms are specifically required under the *Mines Regulation Act Regulations 1976* and are excluded from the allowable limits under the draft noise Regulations. Worsley has recently fitted quieter alarms to reduce their impact on neighbours while maintaining mine safety standards.

Worsley has monitored, in accordance with Part V licence conditions, the airblast overpressure from each blast at the nearest residence.

## Table 8: Sound Reduction Measures at the Bauxite Mine

| FIXED PLANT | COMPLETION COMMENTS |
|---|---|
| Sealed primary hydraulic room. | Item Complete. |
| Relocate shuttle - bin feed points. | Item Complete. |
| Install rubber backed wear plates in certain areas. | Currently under Trial. |
| Replace hydraulic pumps in the primary & reclaim areas with quieter units | Initiative Partially Complete. |
| Removal of lube system warning alarms. | Initiative Partially Complete. |
| Utilisation of rubber screen mats. | Item Complete. |
| Rubber lining of screen undersize chutes. | Item Complete. |
| Lubrication of primary crusher apron feeder bed. | Item Complete. |
| **MOBILE PLANT** | |
| Install smart reverse alarms to all equipment. | Item Complete. |
| Trial improved smart alarm + revolving light. | Currently under Trial. |
| Trial low noise engine covers on trucks. | Currently under Trial. |
| Trial radiator baffles and fan shrouds on trucks. | Currently under Trial. |
| Modification to tray exaust outlet and diverter box arrangements on trucks | Item Complete. |
| Install increased horsepower engines in trucks. | Positive reduction effects partially offset by Increased Sound Power. Ongoing. |
| Install alternative truck exhaust mufflers. | Initiative Partially Complete. |
| Replace leibherr r991 excavator with pc1600 excavator. | Item Complete. Negative Effect due to Increased Sound Power. |
| Increase level of maintenance on dozer track chains. | Item Complete. |
| Install improved komatsu w70 engine cover. | Item Complete. |
| Replace rotary drill with hammer drill. | Item Complete. Increased Sound Power. |
| Install improved scraper engine covers. | Item Complete. |
| Install attenuator to 992c fan. | Initiative Partially Complete. |
| Attenuate mobile lighting plants. | Initiative Partially Complete. |
| **OPERATIONAL** | |
| Trial radio signaling in place of horns. | Currently under Trial. |
| Run two drills on day shift - reduce after dark drilling. | Item Complete. |
| Instigate lower rev tipping of trucks at primary hopper. | Initiative Partially Complete. |
| Load first bucket of fine material into truck tray. | Item Complete. |
| Load fine material into primary hopper first. | Item Complete. |
| Restrict gear changes when climbing long steep ramps. | Item Complete. |
| Instigate a night shift maintenance crew. | Item Complete. Negative Impact. |
| Modify blast design to reduce airblast. | Item Complete. |
| Increase average number of holes per blast. | Item Complete. |
| Extend production operating hours. | Item Complete. Negative Impact. |
| Reduce requirement for weekend operations. | Item Complete. |
| Increase overall haul distance within str. | Item Complete. Negative Impact. |
| Restrict engine revs allowable in workshop. | Item Complete. |
| Replacing impact tools with quieter models. | Initiative Partially Complete. |
| Improve design and profiling of haulroads. | Initiative Partially Complete. |
| Replace some blasting with hardcap ripping. | Item Complete. Positive Impacts Partially Offset by Ripping Noise. |
| Restrict mine operating areas during noise sensitive times. | Item Complete. |
| **PROPOSED INITIATIVES** | **NOISE REDUCTION POTENTIAL** |
| **FIXED PLANT** | |
| Double skin one secondary crusher. | High Potential Reduction. |
| Replace further hydraulic pumps with quieter units. | Low Potential Reduction. |
| Attenuate dust filters. | High Potential Reduction. |
| Acoustically treat secondary crusher drive motors. | High Potential Reduction. |
| Acoustically treat secondary screens and oversize chutes. | High Potential Reduction. |
| Enclose primary crusher apron feeder drives. | Low Potential Reduction. |
| **MOBILE PLANT** | |
| Trial rubber lining of truck tray. | High Potential Reduction. |
| Install attenuated cowlings to all major mobile equipment engine bays. | High Potential Reduction. |
| "Trial adjustable speed, adjustable pitch fan blades." | High Potential Reduction. |
| Fit resonators to cat 992c exhausts. | High Potential Reduction. |
| Develop a noise reduction kit for the d575 track dozer with komatsu | High Potential Reduction. |
| **OPERATIONAL** | |
| Open up mining areas in each sector to provide noise control alteratives. | Medium Potential Reduction |
| Model mining noise use ENM software. | High Potential Reduction. |
| Relocate operations to core areas when modelling predicts a noise problem. | High Potential Reduction. |

Compliance with Environmental Protection Act licence conditions over the last eight years is summarised in Table 9.

**Table 9: Airblast Overpressure Monitoring Results**

| Licence No | Period | Licence Conditions | Monitored Compliance | Blasts >120 dB(lin) peak |
|---|---|---|---|---|
| 1447 | Sept 1989 | 95% <120 dB(lin) peak | 99% <120 dB(lin) peak | 2 |
| | Aug 1990 | 90% <115 dB(lin) peak | 92.6%<115 dB(lin) peak | |
| 2246 | Sept 1990 | 95% <120 dB(lin) peak | 100%<120 dB(lin) peak | 0 |
| | Aug 1991 | 90% <115 dB(lin) peak | 100%<115 dB(lin) peak | |
| 3132 | Sept 1991 | 0>125 dB(lin) peak | 0>125 dB(lin) peak | 2 |
| | Sept 1992 | 8>120 dB(lin) peak | 2>120 dB(lin) peak | |
| | | 8>115 dB(lin) peak | 3>115 dB(lin) peak | |
| 3838 | Oct 1992 | 0>125 dB(lin) peak | 0> 125 dB(lin) peak | 1 |
| | Sept 1995 | 8>120 dB(lin) peak | 1> 120 dB(lin) peak | |
| | | 16>115 dB(lin) peak | 5> 115 dB(lin) peak | |

Compliance with Part V licence conditions has been achieved over the licensing period. Five blasts in excess of 120 dB (lin) peak have been recorded and those have been investigated. In each case, corrective action was identified, taken and incorporated into blasting procedures.

During the period from 1983 to 1989, eleven complaints relating to blasting were received. Since then, eight blast related complaints or comments have been received. Each of these were fully documented and investigated. Where appropriate, modifications to procedures were made.

Ground vibration is routinely monitored, but has never been recorded at significant levels. Whenever new mining pods are opened, the initial blasts are monitored for ground vibration at the nearest residence. For the four years Worsley has been conducting ground vibration monitoring, the vibration level that can be attributed to blasting has been less than the background level. Apparent sensations of ground vibrations at residences are more likely to be the result of low frequency, inaudible airblast overpressure and its secondary effects on the premises. The recorded levels of airblast (including audible and inaudible) are well below that which is generally regarded as causing damage to competent structures.

Over the 12 years of mining operations to date, Worsley has investigated six complaints relating to structural damage attributed to blasting. On all occasions the complaints were investigated either by independent experts or by Worsley. In each of the six cases, there was a clear structural or foundation reason for the damage and no evidence suggesting that blasting was the cause.

*Mining Noise Management Commitments*

31. Amend mining operations as necessary to comply with noise regulations.

32. Predict sound levels for mining operations and routinely verify the output of the ENM model.

33. Continue with the outlined program of sound power reduction initiatives for mining equipment and fixed plant.

34. Plan mine development to facilitate the management of sound levels from mining operations.

35. Specify low sound power levels and minimum unfavourable sound characteristics as far as practicable when selecting new mining equipment and plant.

36. Monitor the air blast over pressure level of each blast at the most sensitive premises and report the findings to the DEP annually.

37. Investigate and identify corrective action when any blast creates air blast overpressure greater than 110 dB(lin) peak at a monitoring location.

38. Report to the DEP any blast that creates airblast overpressure greater than 120 dB(lin) peak.

39. Measure ground vibration levels when new areas are opened for mining.

40. Investigate complaints and take corrective action where required.

### 5.2.7 Dust management

*Objective*

To comply with statutory requirements so that the amenity of nearby residences is protected from dust impacts resulting from bauxite mining activities.

*Existing Conditions and Commitments*

Under Part V licence conditions, Worsley is required to minimise dust emissions by the use of appropriate dust suppression methods.

Worsley's dust management program is based on ERMP commitments minimising dust emissions from the haulroad network using groundwater and surface water.

*Potential Significance Impact*

Bauxite is transported from a mine-pit area to the primary crusher by 85 tonne dump-trucks along a network of haulroads to the primary crusher plant. Dump truck movement can result in dust emissions. Blasting, mining equipment operation, crushing and stockpiling all have the potential to cause dust emissions.

*Dust Management Strategy*

Worsley's dust management strategy is designed to minimise dust emissions by using dust-suppression methods such as the watering of the haulroads. Other methods of dust-suppression such as the amendment of inert materials on the haulroads are currently being trialled as alternatives.

The strategies designed to mange mining noise and air blast overpressure emissions (see Section 6.2.6) take into account the prevailing weather conditions including wind speed and wind direction. This minimises potential impacts of dust emissions from those operations.

Haulroad watering is the principal dust suppression method used by Worsley to minimise dust emissions and the continued use of this method will ensure that the potential impacts on the environment are negligible.

*Mining Dust Management Commitments*

41.Use water on haul roads and fixed plant to suppress dust.

42.Trial additives to increase the efficiency of water as a dust suppressant.

### 5.2.8 Public Access and Safety

*Objectives*

To restrict access by the general public to the mine operating areas in accordance with safety requirements.

*Existing Conditions and Commitments*

In the ERMP Worsley undertook to:

- post safety officers to ensure that areas are clear of personnel during blasting;
- close forest roads in the active mine area (following consultation with CALM);
- establish and signpost by-pass roads where necessary; and
- re-establish the forest road network after mining (following consultation with CALM).

*Potential Significance of Impact*

Potential hazards to the community associated with bauxite mining relate principally to blasting and mine traffic on haulroads in operational areas of the mine. Restrictions on access are required to prevent harm to members of the public but may also reduce the recreation use of areas and cause closure of public roads near the mine.

The Saddleback, Marradong and Quindanning Timber Reserves have not been developed for recreation. In the absence of the mining operation, it is expected that limited use would be made of the areas.

### *Public Safety Management Strategy*

The management strategy aims to prevent access and exposure to mine hazards but not to unnecessarily inconvenience or limit public enjoyment of forest recreation areas adjacent to mining areas.

Since the approval of the ERMP and the commencement of mining operations in 1983 there have been three significant developments which influence the management of public access. They are:

- the mining operation has become more widespread (haul distances are longer) and closer to residences, agricultural areas and public roads;
- haul roads cross public roads; and
- ripping in lieu of blasting of shallower hardcap is cost effective, thereby reducing the safety buffer requirement in some areas.

The perimeter of the mining operations and blasting buffer area on Crown or private land is fenced and/or warning signs posted to prevent inadvertent access. Forest tracks are gated at the perimeter but CALM retains access for fire fighting purposes. The mine entry gatehouse is staffed whenever people are working on the site. Security gates and fences are locked when the gatehouse is not attended.

When blasting is required it is routinely carried out between 12:15 and 1:00 pm on weekdays. Prior to blasting, formal clearances of affected roads and areas within 400m of the blast by Worsley personnel are carried out and sentries are posted. A warning siren is also sounded before blasting.

Haulroad crossings of infrequently used public roads (eg Flatter Road) and the mine access road are staffed during hauling. Large mining equipment is individually flagged across the roads if the crossings are not staffed.

### *Public Access and Safety Commitments*

43. Maintain perimeter security fencing and signposting and gate, or otherwise block-off forest tracks by arrangement with CALM.

44. Clear blasting areas and post sentries prior to and during blasting.

45. Seek State approval of mine and public road intersections and management arrangements.

46. Re-establish the forest road network after mining, in consultation with CALM.

### 5.2.9 Waste management

*Objectives*

To reduce as far as practicable the generation of solid and liquid wastes resulting from bauxite mining activities.

To dispose of waste in an environmentally acceptable manner.

*Existing Conditions and Commitments*

The disposal of waste generated by industry is regulated by licence or regulations under the *Environmental Protection Act, 1986.* The disposal of used tyres is regulated under the *Environmental Protection Regulation, 1987 (as amended)* and the deposit of wastes into municipal landfills is controlled under the *Health Act 1911 - 1987.*

Worsley has implemented a waste management strategy pursuant to commitments made in the ERMP. This strategy involves minimising waste generated by mining activities and by containment of wastes and off-site disposal under controlled conditions.

*Potential Significance of Impact*

Wastes produced at the minesite are collected and recycled or disposed of offsite into a landfill. The application of existing management procedures for wastes produced by mining operations ensures that that the disposal of wastes does not give rise to a significant impact on the environment.

The current and projected annual production rate for wastes generated at the minesite are shown below in Table 10.

**Table 10: Waste Products Generated Annually at the Minesite.**

| Waste | Quantity of Waste (current) | Projected Increase (%) | Reuse/Disposal Method |
|---|---|---|---|
| Waste Oil | 92 kilolitres | 60 | recycle offsite |
| Treated Oily Sludge | 50 kilolitres | 20 | offsite treatment |
| Treated waste water | 600 kilolitres | 20 | road watering |
| Sewage | 1 $m^3$ | 50 | septic |
| Scrap Steel | 70 tonnes | 20 | recycle offsite |
| Light vehicle tyres | 120 | 50 | recycle offsite |
| Heavy vehicle tyres | 70 | 50 | returned to supplier |
| Inert and Putrescible Wastes | 650 $m^3$ | 50 | landfill |

*Waste Management Strategy*

Worsley's waste management strategy has been designed to protect the environment by minimising the generation of wastes disposed of into landfill by reuse or recycling.

Where reuse or recycling is not practicable the waste is disposed of in secure landfill operated by the Shire of Boddington or removed by licensed waste contractors for treatment or disposal.

The individual waste management strategies for minesite wastes are described below.

*Waste Oil*

Waste oil is currently removed from site by licensed contractors and used for bunker fuel or recycled. The installation of waste oil storage tanks and treatment equipment is scheduled in 1996 for onsite recycling and reuse of some waste oil.

*Oil/Water Waste and Sludges*

An Anpress waste treatment unit is used for separating water from oily wastes. The oily sludge recovered after treatment is collected by licensed contractors and disposed of at the Forrestfield Waste Treatment Plant. The waste water from this process, in combination with collected stormwater, is used for dust-suppression on haul roads.

*Scrap Metal and Light Vehicle Used Tyres*

Scrap metal is reused where ever possible on site. Unusable scrap metal is collected by licensed contractors for recycling. Light vehicle use tyres are disposed offsite for recycling.

*Heavy Vehicle Used Tyres*

Partially worn tyres are re/matched as necessary and re-fitted for use. Second-hand tyres are purchased as necessary to provide matched sets. Worn-out tyres are returned to the supplier.

*Inert and Putrescible Wastes*

General waste suitable for disposal into landfill is disposed of offsite to the Boddington landfill site. This landfill site has insufficient capacity to meet long term disposal requirements and Worsley is assisting the Shire to secure a new landfill site.

***Mining Waste Management Commitments***

47. Investigate where practicable, alternatives for on-site reuse/recycling of waste oil.

48. Assist the Shire of Boddington to locate an additional landfill site to meet the future waste disposal needs of the local community and Worsley.

## 5.3 OVERLAND BAUXITE CONVEYOR

### 5.3.1 Forest Protection

*Objective*

To ensure operation of the overland conveyor has minimal impact on forest ecology.

To minimise the risk and spreading of jarrah dieback in forest areas adjacent to conveyor operations.

*Potential Significance of Impact*

The overland conveyor traverses predominantly State Forest, a large portion of which is quarantined to prevent the spread of jarrah dieback. The operation of the conveyor has the potential to impact upon forest values relating to timber resources, water catchment areas, recreation and habitat for flora and fauna. The movement of maintenance and general vehicles along the conveyor corridor has the potential to spread dieback by transport of contaminated soil.

Concerns raised in response to the draft ERMP suggested the placement of the conveyor through areas of quarantined forest would increase the risk of dieback infection, particularly during construction when major earthworks and vehicle movements would take place. Concern was also raised with regard to the conveyor impeding movement of fire fighting equipment through the forest in the event of wildfire, and controlled burns.

The risk of spread of dieback is minimal given the application of forest hygiene measures and the fact that there will be no clearing of forest along the conveyor corridor associated with the proposed expansion.

*Existing Environmental Conditions and Commitments*

Existing environmental management measures relating to the construction and operation of the overland bauxite conveyor have been detailed in the ERMP. Management measures will continue to address issues of dieback management, surface water management, flora and fauna, noise control, dust control, visual impact, fire protection, and public safety and access.

*Forest Protection Strategy*

Environmental management measures which have been developed and implemented include:

- Restrict public access to only authorised personnel;
- Maintain safety features, such as fencing and securing the conveyor corridor, culverting the conveyor at public road crossings, appropriate warning signs, trip cables and start-up warning devices;
- Minimise dust generation by maintaining sealed service roads and conveyor covering;

- Fire protection by equipping conveyor patrol vehicles with knapsack sprays, spark arrestors and two-way radios, and maintenance of effective firebreaks around drive housings and substations;

- Maintain maximum speed limit of 60 km/h along the service road to ensure safety of personnel;

- Maintain coloured conveyor sheeting to reduce visual impact; and

- Minimise any cleared areas, and prompt rehabilitation of bare areas where practicable to retain floral characteristics and fauna habitat.

The conveyor corridor (average width of 30 m) is managed as a controlled drainage system, with operational activities being restricted to this corridor. The drainage system captures all water, and spillage of bauxite from the conveyor is contained within the corridor. Stormwater is directed to valleys and discharged into natural drainage zones. In areas where there is a potential for water turbidity problems, silt traps and/or vegetated filter beds have been constructed to capture sediment.

To meet the major commitment of minimising the spread of jarrah dieback, Worsley has developed an Overland Bauxite Conveyor Forest Disease Hygiene Prescription (Appendix 7). This procedure is to ensure that the activities of Worsley or its contractors do not contribute to the spread of the jarrah dieback disease.

Essential maintenance activities outside of the controlled drainage area are only carried out under dry soil conditions. All machinery and vehicles are cleaned prior to leaving the controlled drainage area, and if working in potentially infected areas, are again cleaned prior to moving back into the conveyor corridor.

Any vehicles using the conveyor service road are issued with quarantine permits on behalf of CALM. Details of Worsley's Overland Bauxite Conveyor Forest Disease Hygiene Prescription are attached to the quarantine permit.

Worsley and CALM also enter into an annual Interagency Agreement for hazard reduction burning and wildfire suppression. This Agreement ensures collaboration and assistance in the event of wildfire.

***Monitoring Program and Past Performance of Strategy***

Regular inspection of the conveyor corridor in conjunction with CALM has shown Worsley's dieback management to be successful over the 10 years of operation. Two isolated outbreaks of dieback (of less than one hectare) were detected in 1992. In consultation with CALM, these infected areas were treated with phosphorous acid (Fos-jet 200 ®) to rehabilitate the areas. The source of these infections is unknown, but may be linked to either construction of the conveyor, or previous logging of the area.

The contained drainage system has been strengthened in the vicinity of the infection sites by the addition of silt traps in the valley floors to increase retention of surface water and sediment within the conveyor corridor.

Rehabilitation of areas cleared for the construction of the conveyor is proving to be successful and no soil erosion or interruption to water runoff have occurred. The conveyor corridor has proven to be an attractive site for bird breeding activities in the dense vegetation within the rehabilitated areas. Breeding activities have been found to be higher than in adjoining forested sites (Ninox, 1992).

***Overland Conveyor Forest Protection Commitments***

49. Continue implementation of the Overland Conveyor Forest Disease Hygiene Prescription to minimise the spread of jarrah dieback.

50. Conduct periodic review of the Overland Conveyor Forest Disease Hygiene Prescription in consultation with CALM.

51. Conduct regular inspection and monitoring of forest health within and adjacent to the overland conveyor corridor in conjunction with CALM.

52. Continue the annual CALM Interagency Agreement for Wildfire suppression.

53. Conduct periodic monitoring to measure the success of fauna habitat protection.

### 5.3.2 Noise Management

*Objective*

To ensure noise emissions from the conveyor comply with statutory requirements.

***Potential Significance of Impact***

The conveyor traverses State Forest for the majority of its length, but crosses private land in a small section of the Hotham and Murray River valleys (Figure 20). Residents in proximity to the conveyor, under certain conditions, may experience noise emissions from the operation of the conveyor, and associated maintenance activities.

At the time of the preparation of the draft ERMP, comment was made that noise emissions could potentially affect fauna activities in the vicinity of the conveyor, and fauna crossing the conveyor corridor (section 5.3.1).

***Existing Environmental Conditions and Commitments***

The ERMP has formed the basis for environmental commitments relating to noise emission from the overland bauxite conveyor up until 1995. Amendment to the *Alumina Refinery (Worsley) Agreement Act 1973* in July 1995 now prescribes the noise and compliance monitoring standards for the conveyor.

The Agreement provides for 24 hour operation of the bauxite conveyor subject to compliance with prescribed noise standards. Noise emissions from the conveyor are required to be continuously monitored at a reference point 900 m from the conveyor to ensure compliance with an upper limit of 60 dB(A). Results of the monitoring program are reported to the State annually.

Commitments are listed at the end of this section.

***Noise Management Strategy***

When the overland bauxite conveyor was commissioned in 1984, noise levels exceeded the manufacturer predictions, since then Worsley has been engaged in an extensive noise mitigation program. Worsley has investigated a number of options for decreasing noise emissions from the conveyor.

Consistent with Worsley's policy of continual improvement, investigation of options for reducing noise emission from the conveyor in proximity to noise sensitive areas is ongoing, even though noise levels are within prescribed standards.

The overland conveyor is a cable belt conveyor system consisting of a belt laying on top of steel cable which in turn is supported by a system of pulleys. A schematic section of the conveyor is shown in Figure 21

Studies carried out by Worsley have shown the major source of noise emission from the conveyor is the impact of the conveyor cable over pulleys. This source produces frequency components at 105, 210 and 310 Hz which can be projected over long distances under certain weather conditions.

The standard conventional, 320 mm diameter pulleys used on the conveyor include a hard polyurethane "tyre" on the outer rim. Modifications of these pulleys has been undertaken to increase the contact area between cable and pulley by reducing the hardness of this polyurethane outer rim.

These pulley modifications have resulted in an overall average noise reduction at source of 10 dB(A) compared with conventional pulleys (Sound and Vibration Technology, 1995).

Since 1993 Worsley has installed approximately 15 km of modified pulleys throughout areas adjacent to, or in proximity to private land holdings. Negotiated arrangements have also been reached with individual land owners.

Many other noise mitigation treatments of conveyor equipment have been investigated. However, in addition to the modified pulleys, the installation of polyurethane inserts at all metal to metal contact points and replacement of metal covers with fabric covers over the conveyor have proven the most successful at reducing noise emissions.

Throughout areas adjacent to residences, metal covers have been replaced with canvas resulting in noise reductions in the order of 6 to 10 dB(A).

Since 1989 modifications to the conveyor system designed to reduce noise emission have been carried out at a total cost of $11M. Further noise reductions will be proportionally more difficult to achieve and may not be technically feasible.

Worsley has prepared a noise management policy which ensures conveyor noise levels will be contained within the 60 dB(A) limit prescribed under the Agreement. If noise levels reach 55 dB(A) the policy requires mitigation measures to be implemented. If, after taking this action, the 60 dB(A) standard is exceeded the policy requires the conveyor to be shutdown.

***Monitoring Program and Past Performance of Strategy***

Worsley has carried out detailed monitoring work which has involved octave and narrow band noise assessments to identify the frequencies and source of noise emissions from the conveyor. In addition overall noise assessments have been made by the consultants Sound and Vibration Technology in accordance with relevant Australian Standards for noise assessment. The monitoring program has formed the basis of the noise management strategy detailed above by providing real time feedback on noise levels to Worsley personnel who operate the conveyor.

Prior to implementing the noise mitigation program overall noise from the conveyor was in the order of 80 dB(A) at source, decaying to 30 - 35 dB(A) within one kilometre of the conveyor (Figure 22). The replacement of conventional pulleys with modified pulleys has reduced noise levels by an average of 10 dB(A).

Monitoring has also shown that the modified pulleys retain their noise reduction properties over their operating life (Figure 22). However the softer polyurethane compounds result in greater wear and necessitate more frequent pulley changeover. Worsley are continuing to test prototype pulleys which will tolerate greater wear but maintain lower noise emissions.

A continuous noise monitoring station has been installed at the refinery to ensure noise emission levels from the conveyor do not exceed the specified 60 dB(A) upper limit. Results of the monitoring will be reported to the State annually.

***Overland Conveyor Noise Management Commitments***

54. Investigate where practicable, noise mitigation measures to reduce noise emissions from the conveyor in proximity to noise sensitive areas.

55. Monitor noise emission from the overland conveyor to ensure compliance with the present limit of 60 dB(A) limit as prescribed under the 1995 amendment to the Agreement Act.

## 5.4 REFINERY AND BAUXITE RESIDUE MANAGEMENT

### 5.4.1 Atmospheric Emissions

*Objective*

To comply with statutory requirements so that the ecological values of off-site areas, and the amenity and health of nearby residents are protected from adverse atmospheric emissions from the refinery operations.

*Potential Significance of Impact*

The primary emissions from the refinery site are sulphur dioxide ($SO_2$), oxides of nitrogen ($NO_X$) and particulates from the powerhouse and calciners. In addition, dust from materials handling facilities and fugitive dust from around the site, and odours may also arise from the refinery.

The installation of the proposed liquor burning facility may also produce volatile organic compounds and resultant odours as a result of burning off the organic impurities in the process liquor.

The isolated location of the refinery away from populated areas and other industry generally reduces any nuisance impact atmospheric emissions may have on surrounding neighbours or vegetation. However sulphur dioxide emissions, when combined with concentrations resulting from the Muja power station and the proposed Collie power station, may have the potential to impact upon nearby residents and surrounding forest.

The buffer area between the refinery boundary and the near residences is not permanently occupied and is used intermittently (section 6.5).

*Existing Environmental Conditions and Commitments*

The ERMP forms the basis for existing commitments which relate to minimising and monitoring atmospheric emissions.

The Part V licence held by Worsley sets conditions for the emission of $SO_2$ and particulates from the powerhouse and calciner stacks. These conditions stipulate that:

- the concentration of particulates in the exit gases from any stack shall not exceed 250 $mg/m^3$.

- the mass emission of $SO_2$ from the powerhouse stack shall not exceed 520 g/s.

There are currently no formal ambient air quality statutory standards throughout Western Australia. However, the Government has promulgated two Environmental Protection Policies for atmospheric contaminants in the Kwinana and Kalgoorlie areas. The Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1992 specifies ambient standards and limits for sulphur dioxide and particulates for three air quality

zones. These are for the industrial zone, buffer zone and area outside the buffer zone (residential). The standards and limits[4] for these areas are summarised in Table 11.

Worsley have adopted these standards as guidelines for air quality for use in monitoring and modelling programs.

**Table 11: Ambient Air Quality Standards and Limits for Sulphur Dioxide and Particulate Emissions (Kwinana EPP).**

| Emission | Zone | Averaging Period | Standard ($\mu g/m^3$) | Limit ($\mu g/m^3$) |
|---|---|---|---|---|
| Sulphur Dioxide | Industrial estate | 1 hour | 700 | 1,400 |
| | | 24 hour | 200 | 365 |
| | | annual | 60 | 80 |
| | Buffer area | 1 hour | 500 | 1,000 |
| | | 24 hour | 150 | 200 |
| | | annual | 50 | 60 |
| | Residential | 1 hour | 350 | 700 |
| | | 24 hour | 125 | 200 |
| | | annual | 50 | 60 |
| Particulates | Maximum | 15 minute | - | 1,000 |
| | Industrial Estate | 24 hour | 150 | 260 |
| | Residential | 24 hour | 90 | 150 |

For nitrogen dioxide Worsley has used the Australian Environment Council/National Health and Medical Research Council guidelines (1986). These guidelines state that 320 $\mu g/m^3$ is not to be exceeded more than once a month.

The guidelines take into account effects of emissions on public health and on vegetation. Levels which protect health are not expected by Worsley to adversely impact vegetation.

***Management of Atmospheric Emissions***

Worsley is required by Part V licence conditions to provide for monitoring emissions of $SO_2$ and particulates from the powerhouse and calciner stacks. Although not subject to a statutory condition, the emission of $NO_X$ is also periodically monitored. Levels of $SO_2$ and particulates are required to be reported to the DEP if any licence condition is exceeded. Monitored emissions are shown in (Table 12) and are well within licence conditions. These levels will remain within licence conditions following the expansion.

Based on the mass emission rate, sulphur dioxide is the most significant source of atmospheric emissions. Particulate emissions from all stacks at the refinery are

[4]Standard means the concentration of an atmospheric waste which it is desirable not to exceed. Limit means the concentration of an atmospheric waste which shall not be exceeded.

negligible due to the operation of electrostatic precipitators or fabric filters on the power station and calciner stacks.

The impact of the refinery expansion on atmospheric emissions have been determined by WNI Science and Engineering using numerical dispersion models and monitored sulphur dioxide data from Collie (WNI, 1995). Estimates of the ground level concentrations from stack emissions were determined using AUSPLUME, the Victorian EPA's dispersion model, and convective analysis techniques using the morning fumigation model of Deardorff and Willis (1982). Data used from the modelling was sourced from the extensive air quality and meteorological measurements obtained near Muja by SECWA in 1983 and 1984.

**Table 12: Emission of Sulphur Dioxide, Particulates and Oxides of Nitrogen from the Refinery.**

| Source | Mass Emission Rates (g/s) and Concentration ($mg/m^3$)* | | |
|---|---|---|---|
| | $SO_2$** | Particulates*** | $NO_x$*** |
| Existing refinery capacity | | | |
| Powerhouse | 304 (359) | 25.4 (30.1) | 97 (115) |
| Calciners (per unit) | 0.08 (0.16) | 14 (28.4) | 0.42 (0.85) |
| Refinery expansion[5] | | | |
| Powerhouse | 454 (340) | No change | 164 (123) |
| Calciners | 0.42 (0.85) | No change | 1.2 (2.4) |

* Concentrations are shown in brackets
** Calculated by sulphur content in coal; assuming 100% conversion to $SO_2$
*** Monitored in stacks; average of quarterly samples.

*Sulphur Dioxide*

The predicted maximum hourly, 99.9 percentile, maximum daily and the annual average concentrations of $SO_2$ and those predicted for the nearest residence are summarised in Table 13. These estimates included contributions from the existing Muja power station and the proposed new Collie Power Station.

Table 13 indicates that for sulphur dioxide, maximum hourly and 9th highest hourly average concentrations will be 866 and 451 $\mu g/m^3$. These peak concentrations are predicted to occur at distance of 0.5 to 1 km from the powerhouse and calciner stacks and within the Worsley refinery lease area (Figures 23 and Figure 24). These values are higher than the residential zone standards of 700 and 350 $\mu g/m^3$, but are well below the industrial zone standard of 1400 and 700 $\mu g/m^3$.

[5] Assumes "worst case" of the additional boiler being coal fired.

At the nearest residential site, the maximum and 9th highest hourly concentrations of $SO_2$ will be 350 and 150 $\mu g/m^3$, which are well below residential air quality standards. The highest maximum 24 hour and annual average concentrations of 88 and 10.4 $\mu g/m^3$ respectively are also well below the standards. At the refinery lease boundary the buffer zone standards are met (Figures 23 and 24).

To simulate the effect of morning fumigation the model of Deardorff and Willis (1982) was used. Morning fumigation refers to the situation where a plume in stable night air, at a height of a few hundred metres, is mixed rapidly to the ground as the result of heating the ground surface after sunrise. This process can result in high concentrations over a period of 30 to 60 minutes in the morning. Results of this modelling indicate that at downwind distances of 6 and 15 km (less than the distance to the nearest residence and Collie) the most likely worst case concentrations would be 445 and 382 $\mu g/m^3$ respectively. Therefore, fumigation will not result in adverse impacts on air quality within the region.

**Table 13: Predicted Ground Level Concentration of Sulphur Dioxide (using AUSPLUME).**

| Emission | Averaging Period | Existing Operations | | Refinery Expansion | |
|---|---|---|---|---|---|
| | | Maximum | Nearest Residence | Maximum | Nearest Residence |
| $SO_2$ ($\mu g/m^3$) | Max 1 hour | 586 | 280 | 866 | 350 |
| | 9th highest hour | 280 | 130 | 451 | 150 |
| | Max 24 hour | 63 | 32 | 88 | 32 |
| | Annual average | 6.9 | 4.0 | 10.4 | 5.5 |
| $NO_2$ ($\mu g/m^3$) | Max 1 hour | 146 | 93 | 157 | 93 |
| | 9th highest hour | 61 | 40 | 82 | 43 |
| | Max 24 hour | 16.3 | 11.5 | 21.8 | 11.5 |
| | Annual average | 1.6 | 1.3 | 2.4 | 1.3 |
| Particulates ($\mu g/m^3$) | Max 24 hour | 1.11 | 0.4 | 1.35 | 0.5 |
| | Annual average | 0.11 | 0.06 | 0.13 | 0.07 |

These concentrations have been determined using hypothetical worst case meteorological conditions which are unlikely to occur even once per year. Regional air quality monitoring in Collie over a four month period has indicated $SO_2$ concentrations of only 25 $\mu g/m^3$ to be attributable to Worsley (WNI, 1995), indicating the fumigation modelling performed is likely to be conservative.

The emission of sulphur dioxide was reduced from the calciners as a result of the 1985 conversion from fuel oil to natural gas (which has negligible sulphur content).

Installation of a new boiler and calciners, and retrofit of old equipment if practicable will incorporate best practicable pollution suppression technology.

*Oxides of Nitrogen*

Oxides of nitrogen are made up of NO, $NO_2$ and $N_2O$, of which the most significant environmental contaminant is $NO_2$. Therefore, ground level concentrations have been modelled for $NO_2$ only.

For nitrogen dioxide the maximum hourly, 9th highest hourly, maximum 24 hour and annual average concentrations will be 157, 82, 21.8 and 2.4 $\mu g/m^3$ respectively (Table 13). These values are well below the standards and indicate that $NO_2$ emissions will have insignificant effect on regional air quality.

*Particulates*

Ambient ground level concentrations of particulates will be negligible. The proposed expansion will lead to maximum 24 hour and annual average concentrations of 1.35 and 0.13 $\mu g/m^3$ for locations close to the site (Table 13).

Electrostatic precipitators installed on all stacks reduce the emission of particulates.

*Odour*

Odours may arise from three sources at the refinery site. The first involves the reaction of caustic soda and organic material within the bauxite ore, principally in the digestion area. The second involves the potential for emission of hydrogen sulphide from a solar evaporation pond which has, in the past produced significant odours. The third source of odours is from the proposed liquor purification facility (see volatile organic compounds below).

Hydrogen sulphide results from biological activity in a solar evaporation pond which was also used for co-disposal of sodium oxalate. Biological activity is stimulated by the sodium oxalate which provides a carbon substrate for bacterial activity. Since oxalate disposal into the pond was ceased in 1989, emission of odours has been reduced to very low levels and occurs occasionally in autumn as a result of "pond turnover". Detailed reports on the emissions from the solar evaporation ponds were provided to the DEP in September and December of 1989.

As a result of extensive research and development following this incident, the bacteria isolated from the solar evaporation pond are now used in a controlled environment for the bioremediation of sodium oxalate in the refinery. This bioremediation process does not evolve hydrogen sulphide.

*Dust*

At the refinery fugitive dust arises predominantly from the residue disposal areas (section 5.4.3). Other potential sources of dust are the dry materials handling facilities

around the process area such as the bauxite stacking and reclaim areas, and product loading facilities.

Bauxite stackers are equipped with water jets for dusts suppression. All raw materials and product handling facilities are equipped with dust extraction systems. Routine baghouse maintenance ensures dust emissions are kept to a minimum around the site.

Volatile Organic Compounds

The oxidation of organic impurities within the process liquor associated with the proposed liquor purification facility may result in emission of low concentrations of volatile organic compounds (VOCs). Liquor purification technology is currently employed at other alumina refineries. Quantification of liquor purification facility emissions shows stack concentrations of VOCs to be well below threshold limit values. It is expected that as a result of dilution and dispersion of VOCs, ground level concentrations will be well within air quality standards (eg Victorian EPA, 1981). Investigations will be undertaken to quantify emissions and ground level concentrations of VOCs from the proposed liquor purification facility.

***Refinery Atmospheric Emissions Commitments***

56. Monitor gases and particulate emissions from the powerhouse and calciner stacks.

57. Incorporate best practicable pollution suppression equipment on any new plant which discharges to the atmosphere.

58. Monitor ground level concentrations of $SO_2$ and NOx at nearby residences to validate dispersion modelling.

59. Monitor meteorological conditions suitable for prediction of plume rise and dispersion.

60. Quantify emissions of volatile organic compounds from the liquor purification facility.

### 5.4.2 Water Resource Protection

***Objective***

To ensure that environmental values of water resources are maintained from adverse impacts of refinery operations and bauxite residue disposal.

***Potential Significance of Impact***

The refinery is located in the headwaters of the Augustus River and therefore has the potential to affect the quality of this catchment's water resource in the event of the escape of contaminated runoff or groundwater from the site. The major source of potential contaminant is caustic soda, which is present in process waters, and in lesser concentration in bauxite residue. In high concentrations the alkaline caustic liquor can

affect the quality of surface and ground waters, and presents a potential hazard to personnel. However in low concentration the effects of caustic are minimal.

The water resource has important environmental values including maintenance of natural aquatic ecosystems, and public water supply. Concern was expressed in response to the draft ERMP with regard to potential contamination of this resource, its ecological and water supply values and those of the Leschenault Estuary (Department of Conservation and Environment, 1979).

Worsley have adopted the ANZECC water quality guidelines for aquatic ecosystems and water supply as a standard for evaluating the potential impact on the nearby water resource.

### *Existing Environmental Conditions*

The Worsley ERMP approved in 1980 under the State Agreement, forms the basis for environmental conditions and commitments relating to the protection of water resources. Worsley operates a contained water and residue management system and consequently Part V licences for discharges to the environment issued to Worsley do not contain conditions relating to the discharge of effluent to the environment.

A condition of the approval by the Water Authority for the construction of the freshwater lake within the refinery lease area is to maintain a discharge from the freshwater lake of not less than the summer basal flow (approximately 35 cubic metres per hour).

A list of updated commitments is provided at the end of this section.

### *Water Management Strategy*

Worsley is committed to a refinery lease water management system for the life of the project. This system separates clean water from any potentially contaminated water within a water management area for reuse in the refinery (Figure 13). The refinery water management system consists of five key elements:

- A refinery catchment lake, which collects runoff from the refinery, and seepage decant water and runoff from the residue disposal areas. This is used for cooling purposes at the refinery and power station and as process water. The refinery catchment lake is designed to withstand a storm of probable maximum precipitation[6];

- pipehead dams, which are downstream from the residue disposal areas, which collect surface and piped underground drainage from the residue disposal areas and any seepage from under the refinery catchment lake and return these waters to the refinery catchment lake;

- a freshwater lake, which stores clean runoff for use as potable water and as occasional make-up water in the refinery catchment lake;

[6] Probable maximum precipitation is defined as the depth of rainfall which, for any given area and duration can be reached, but not exceeded under known meteorological conditions.

- solar evaporation ponds, for the evaporation of spent cleaning acids and possible containment for sodium sulphate solution from the proposed liquor purification plant; and

- a series of diversion and collection channels to divert clean runoff around to refinery process area and into the freshwater lake.

The only surface water that leaves the refinery lease area is uncontaminated, and is discharged as overflow or scour valve release from the freshwater lake to the Augustus River.

All structures at the Worsley refinery site which contain residue or contaminated water are designed to standards specified by the Australian National Committee on Large Dams which take into account appropriate soil geotechnical properties, storm frequencies and earthquake protection.

Another important strategy in the protection of local surface and groundwaters is Worsley's spills and stormwater management plan which aims to ensure that:

a) the spillage and contaminated stormwater from the refinery site is minimised, and

b) if spills do occur, they are contained and that any contaminated soil is removed and treated, and any contaminated groundwater is recovered and or treated.

The spills and runoff management strategy involves the following measures to prevent, detect, contain and recover or treat contamination.

Prevention of spills by:

- a comprehensive plant monitoring system;

- regular inspection and testing of new and existing storage and process vessels;

- employee education and training in the prevention and management of spills; and

- a system of reporting any incidents to allow corrective action to be taken to prevent recurrence of the incident.

Early detection of spills by:

- regular inspections; and

- an extensive ground and surface water monitoring system (see section 5.6.2 and below).

Containment of spills and contaminant runoff by:

- locating all refinery process vessels on concrete pads. Adjoining areas that are not sealed are progressively being sealed to further reduce risk of contamination of soils. Drainage from process areas reports directly to the refinery catchment lake. Any spillage from these vessels or discharge during facility cleaning is either returned to the process vessel by sump pumps or, if minor, is washed into the refinery stormwater system; and

- capture of all contaminated stormwater and spillage into the controlled refinery water management system.

Recovery and cleanup of contamination by;

- removal and treatment of contaminated soils;

- capture and recovery of contaminated groundwater by a network of recovery bores on the refinery site;

- immediate washdown of any minor spillage to the refinery stormwater system reporting to the refinery catchment lake;

- all spillages are appropriately handled by Worsley's emergency response plan for hazardous materials; and

- return of spillage to process vessels by sump pumps located on the concrete pads.

***Monitoring Program and Past Performance of Strategy***

Worsley has implemented in consultation with the Water Authority a comprehensive monitoring program of both surface and ground waters to ascertain the effectiveness of the water management strategy.

The groundwater monitoring program was established in 1980 prior to construction and refinery start up. Information collected from this period serves as a baseline against which present data can be compared. Monitoring bores are located throughout the refinery lease area (Figure 11) and form a perimeter around the lease and downstream of the major containment components of the management system. Given the direction of groundwater flow toward the valley floors, bores have been concentrated in these areas and around control structures such as bauxite residue disposal area embankments and downstream of the pipehead dam.

Results of the groundwater monitoring program are reported to the Government annually and reviewed by the Water Authority and DEP.

Since start up and in addition to the annual monitoring reports, two major ground water monitoring reviews have been conducted by consultants - BHP Engineering (1986) and Gutteridge Haskins and Davey (1992). These reviews have shown no adverse affect on groundwater levels and quality outside the process area as a result of the refinery or associated operations.

Surface water quality has also been monitored since refinery operations began. Weekly measurements are made of pH and the salinity of water discharging from the freshwater lake to the Augustus River. Throughout the monitoring period no trends are apparent beyond normal seasonal fluctuations (Figure 26). This river water monitoring program is supplemented by periodic survey of the Augustus River to determine impacts on the biota of the river system.

These surveys provide the following information on the riverine system:

- quantitative biological impacts using macro invertebrates in a BACI (before and after, control and impact) experimental design;
- bio-accumulation of heavy metals in freshwater mussels at control and impact sites;
- effects on community metabolism downstream of the freshwater lake; and
- impacts on water quality.

The biological surveys were conducted in 1984 and 1992, and have revealed the following:

- Ecological differences between sites on the Augustus River downstream of the freshwater lake, and the control sites on the Ernest and Brunswick Rivers were minimal (Streamtec, 1993).
- The effects of construction and operation of the freshwater lake were localised with recovery apparent 200 m downstream of the freshwater lake wall.
- No significant adverse impact from refinery operations could be found on macro invertebrate abundance, species richness and species diversity (Figure 25). In fact significant increases in abundance and species richness have been observed.
- The water quality of all sites during both summer and winter was characterised by low salinities (of the order of 120 mg/l) and neutral pH values. All salinities were considerably less than the 550 mg/l water quality criterion for public water supply with no significant difference between the mean salinity levels in the freshwater lake and downstream in the Augustus River.
- Similar and consistent levels of heavy metals at random sites in the Augustus River and the Ernest River control sites were found indicating no significant heavy metal attributable to refinery activities.

In summary the results of monitoring and occasional surveys do not indicate any long term decline in the water quality, effects on river ecology or accumulation of heavy metals in the Augustus River.

During the course of project activities, within the refinery process area localised contamination of groundwater and soil has been detected directly beneath the concrete pads containing some process vessels.

Extensive evaluation of these areas has shown that where caustic process water has penetrated the concrete pad abutment seals and come into contact with the underlying kaolinite clays it has reacted to form a compound known as "zeolite". The formation of zeolite causes swelling of the soil resulting in the upward movement of the overlying concrete foundation pads.

Investigations showed that the isolated contamination of the soil had generally been confined to the upper five metres with some contamination occurring down to 10 metres below the surface in very localised areas.

Cleanup of the contamination is being achieved by dilution and abstraction of contaminated groundwater using a series of freshwater injection and recovery bores around the affected facilities and by the removal and disposal of contaminated soil into the residue disposal areas. Concurrently, concrete pads and foundations are being replaced and geofabric membranes are being installed to prevent further seepage from the facilities.

Upon detection in 1992, the DEP was notified of this contamination and provided with a detailed report with information on:

- the nature and extent of the incident;
- the immediate steps taken to minimise impacts;
- remedial measures planned or undertaken; and
- changes to plant, people and procedures to prevent recurrence.

Worsley will continue to be keep relevant Government agencies appraised of developments in this area through existing statutory reporting mechanisms.

***Refinery Water Resource Protection Commitments***

61. Monitor the quality of groundwater under the refinery lease area, within and downstream from the freshwater lake.

62. Conduct periodic ecological monitoring of the ecosystem immediately downstream of the freshwater lake.

63. Recover or treat any contaminated groundwater.

64. Maintain a basal summer flow of approximately 35 $m^3$/hr from the freshwater lake.

65. Report monitoring results annually to the Government in accordance with provisions of the Agreement Act.

66. Continue to implement the refinery lease water management system designed to separate, contain and where practicable reuse contaminated waste.

67. Implement the spills management plan in consultation with relevant Government agencies.

68. Monitor comprehensively the condition of plant and equipment.

69. Evaluate and periodically update Worsley's emergency response plan for hazardous materials.

### 5.4.3 Disposal of Bauxite Residue

*Objectives*

To design, construct and operate the residue areas in a manner that maintains the integrity of the containment system.

To maximise as far as practicable the extraction of caustic soda from the bauxite residue.

To minimise as far as practicable impacts on the State forest resulting from construction activities.

To manage the residue areas in an environmentally acceptable manner until they meet the requirements of a closure and rehabilitation strategy agreed with the State.

*Potential Significance of Impact*

Prior to disposal, bauxite residue is filtered and washed in the refinery process area to recover as much sodium hydroxide (caustic soda) as possible. At the end of this process small amounts of sodium hydroxide, sodium carbonate and sodium bicarbonate remain in the thick residue.

If not contained, leaching of these alkaline substances and salts from the bauxite residue into the environment would have the potential to affect the quality of nearby water resources in the Brunswick River catchment (refer also section 5.4.2).

On the residue surface, sodium hydroxide is exposed to air and reacts with atmospheric carbon dioxide to form sodium carbonate. If the residue dries out and is exposed to strong winds the sodium carbonate together with silica (from kaolinite) and iron oxide particles may give rise to dust emissions. This dust has the potential to be a source of irritant to personnel and surrounding vegetation.

In response to the draft ERMP, concern was raised with regard to the stability of the system of dry stacking (at the time not previously used in Western Australia) in the residue disposal areas. There was concern that any instability could increase the risk of seepage from the impoundment.

### *Existing Environmental Conditions*

The Agreement and the ERMP form the basis for environmental conditions relating to the methods of disposal of bauxite residue and the construction and management of tailings impoundments.

Proposals for the storage and management of residue have been approved by the Government and require the protection of water resources, and for the progressive rehabilitation of residue disposal areas.

Worsley employ the ambient air quality standards and limits of the Kwinana Environmental Protection Policy for total suspended particulates as a standard within the refinery lease area. The standards and limits are shown in Table 11.

Updated environmental commitments are included at the end of this section.

### *Bauxite Residue Management Strategy*

Worsley employ a system of residue filtration to remove residual sodium hydroxide and to increase solids content to an average of 62%, by weight. The physical properties of the filtered residue are similar to silt. The residue has low strength when saturated, but gains strength as it dries and consolidates.

Worsley has developed and implemented a residue management system which takes into account the chemical and physical properties of the residue and is designed to provide structural integrity to the residue impoundments to prevent the release of contaminated water.

A pollution prevention approach has been adopted in the design and management of residue storage which:

- minimises the amount of alkaline substances in the residue;
- promotes appropriate alternative uses of bauxite residue;
- prevents leakage by a clay seal at the base of the residue disposal areas;
- restricts disposal to the smallest practicable area;
- investigates practicable means of dust generation prevention;
- isolates the residue disposal areas from surrounding areas;
- enhances consolidation of the residue by incorporating the underdrainage in the design of the system; and
- returns drainage to the contained water management system.

The disposal of bauxite residue involves the stacking of low water content residue to keep coverage to a minimum, a clay seal to prevent leakage and underdrainage to

facilitate consolidation and monitoring of the integrity of the clay seal (Figure 14). The residue impoundments are constructed according to specifications of the Australian National Committee on Large Dams.

Under the current 10 year plan for residue disposal, the first residue disposal area is due to be available for rehabilitation by the end of the decade. Worsley has initiated a research program to work toward the development of a rehabilitation prescription for the residue area surface. To date, research has focussed on both engineering and agronomic aspects of rehabilitation by investigating options for ameliorating the chemical and physical limitations to plant growth, characterisation of water balance and settlement parameters. An overview of research to date is given in the Environmental Management of the Worsley Project, Bauxite Alumina and Boddington Gold Mine Operations Triennial Report (Worsley Alumina, 1994).

Development of a closure and long term management strategy for the residue disposal areas is closely linked to development of a rehabilitation prescription. Worsley has begun a program to address closure, this is detailed in section 7.

Rehabilitation of the residue surface will suppress dust generation in the long term. In the shorter term the generation of dust is controlled by alternating deposition of residue between residue areas. The investigation of techniques for establishment of a basal vegetated cover to control dust for longer periods is part of the rehabilitation prescription development program.

Worsley recognises the potential future value of bauxite residue for use as a soil amendment agent, in nutrient adsorption systems, and in industrial applications such as pigmenting, or use in construction. Worsley is at present defining the characteristics of residue for use as a soil amendment agent and in nutrient adsorption systems. However, the full environmental impact of bauxite residue needs to be taken in account when evaluating alternative uses.

In the meantime Worsley will continue to monitor alternative uses for bauxite residue.

***Monitoring Program and Past Performance of Strategy***

The effectiveness of the residue disposal system to prevent potential contamination of nearby water resources is detailed in the water resources protection section (section 5.4.2). Regular measurement of water quality in monitoring bores has revealed that no seepage of alkaline water has been detected outside of the contained water management system. In addition to this monitoring, weekly samples of underdrainage are collected and analysed for potential contamination.

Since refinery operations began in 1984 one localised seepage has been detected from beneath one residue disposal area, this occurred in 1992. The DEP was formally notified of this seepage which was detected by the routine groundwater quality monitoring. At maximum flow the discharge diluted with groundwater from the collection pipe was approximately three litres per second, representing a small leakage from beneath the residue disposal area. Groundwater collected from beneath the residue disposal area was redirected to the contained water management system. This

localised groundwater continues to be redirected and contained. This is expected to continue until the residue disposal area is no longer used.

Monitoring of geotechnical properties and structural stability of the bauxite residue areas is ongoing. Construction of new embankments on the residue impoundments proceeds only when stability testing meets with design safety specifications.

Worsley have a continuous dust monitoring program around the refinery lease area using portable high volume dust samplers.

***Bauxite Residue Management Commitments***

70. Monitor ambient dust throughout the refinery lease area adjacent to the bauxite residue disposal areas.

71. Minimise fugitive dust from the bauxite residue disposal areas.

72. Develop a rehabilitation prescription for the bauxite residue disposal areas.

73. Develop long term management plan for the bauxite residue disposal areas, which include a closure strategy, in conjunction with relevant Government agencies.

74. Continue to implement a system of quality control for construction of bauxite residue disposal areas.

75. Continue a program to monitor underdrainage from the bauxite residue disposal areas.

76. Monitor alternative uses of bauxite residue.

### 5.4.4 Hazard Management

***Objective***

To minimise the risk of spillage of materials which cause harm to either the environment or personnel.

***Potential Significance of Impact***

A number of potential hazards exist at the refinery site, principally within the process area where large volumes of caustic soda are present. Some process liquors containing caustic are at elevated pressures and temperatures. Also a number of other hazardous materials such as acids and some flammable substances are stored and used at the refinery.

All of these materials represent a hazard to the personnel who work at the refinery site. The principal danger to personnel is burns (either thermal or chemical). In addition spills of these materials may present a potential hazard to the surrounding environment.

### *Existing Environmental Conditions and Commitments*

Principal Acts and Regulations which form the basis of existing conditions at the refinery are:

- Explosives and Dangerous Goods Act;
- Dangerous Goods Regulations;
- Health Act;
- Hazardous and Toxic Substances Regulations;
- Occupational Health, Safety and Welfare Act; and
- Mining Act.

All operational practices relating to the transport, storage and handling of dangerous goods, and safe work practices result from these Acts and Regulations.

### *Hazard Management Strategy*

Worsley has developed and operates under a comprehensive safety standard developed to be in accordance with all relevant legislation. A cornerstone of the safety program is a continued safety and awareness training program. Work crews receive regular training updates, and contribute to the safety program through weekly safety review meetings. A system of incident reporting, and review and analysis of each incident ensures continual improvement of the safety program.

The training program is also extended to site contractors and supporting agencies such as trails and road transporters, who receive training for handling caustic spillage.

Access to the refinery site is controlled through a security system. All new employees, and contractors undergo a safety induction before entry on-site. Follow-up training is given to personnel in specific work areas.

Worsley have developed an emergency response plan for hazardous materials. The response plan covers all aspects of management of incidents including safety, notification of authorities and cleanup measures with concern for both environmental protection and safety of personnel. The emergency response plan is prepared in accordance with the *Explosives and Dangerous Goods Act.*

The refinery site is licensed under the *Explosives and Dangerous Goods Act* for storage of dangerous goods. All dangerous goods stored or handled on-site are catalogued in a HAZMAT and ChemAlert computer system. All personnel have access to this system and can obtain all details for precautions for handling dangerous goods, safety, first aid, and management of spills from this computerised system. To supplement this system, Worsley has a hazard management system of identification and action against potential hazards to minimise the risk of accident or spillage.

Worsley also have a comprehensive system of reporting both safety and environmental incidents. All significant incidents and "near-misses" are recorded, investigated and followed up to prevent recurrence.

Risk assessment has not been performed at the refinery. The process and the isolation of the site both geographically and from other industry, places the refinery in a low risk category.

***Monitoring Program and Past Performance of Strategy***

Worsley's program for hazard management is reflected in the company's achievements in safety and the prevention of any major spills of hazardous materials. Worsley's safety record is good when compared to industry standards, and the company has received numerous awards from the Institute Foundation for Accident Prevention. Two major in-house milestones in safety have also been achieved by passing one million person hours without lost time for injury, on two occasions.

Since refining operations began in 1984, no major spillage of hazardous substances has occurred.

***Hazard Management Commitments***

77. Implement a comprehensive program of safety awareness and training for identification and prevention of hazards.

78. Periodic review of the emergency response plan for hazardous material in accordance with the *Explosives and Dangerous Goods Act.*

### 5.4.5 Waste Management (other than Bauxite Residue)

***Objectives***

To reduce as much as practicable the generation of solid and liquid waste resulting from refinery operations.

To dispose of waste in an environmentally acceptable manner.

***Potential Significance of Impact***

The major waste generated at the refinery is bauxite residue the disposal and management of which is discussed in detail in section 5.4.3. Other wastes generated and method of disposal is provided in Table 14.

***Existing Environmental Conditions and Commitments***

The disposal of waste generated by industry is subject to statutory control and is controlled by licence or subject to regulations pursuant to the *Environmental Protection Act, 1986 (as amended).* The disposal of used tyres is regulated under the *Environmental Protection Regulations, 1987.* The disposal of wastes to municipal landfills is controlled under the *Health Act 1911-79.*

**Table 14: Wastes Generated (other than Bauxite Residue) from Refinery Operations.**

| Waste | Disposal/Reuse Method |
|---|---|
| Sodium Oxalate | Biological destruction |
| Spent acids | Spent (dilute) acid disposed into solar evaporation ponds |
| Waste oils, lubricants and solvents | Removed off-site for reuse or recycling |
| Filter cloths | Bauxite residue area |
| Fibrous materials | Trench burial |
| General waste | Onsite landfill |

In the ERMP, Worsley committed to protecting the environment from waste generated by refinery operation activities, by containment of wastes and off-site disposal under controlled conditions.

***Waste Management Strategy***

Worsley have developed a waste minimisation strategy for the management of each type of waste produced or generated at the Refinery. These strategies aim to minimise the generation and properly contain and dispose of wastes.

The individual strategies for the management of waste are as follows.

*Sodium Oxalate*

Sodium oxalate is formed from the organic impurities in bauxite during processing in the refinery. Oxalate is a hazardous substance, and as such is handled accordingly. Until recently, oxalate had been deposited into prepared trenches in the residue disposal areas. In December 1994 Worsley commissioned a system of bioremediation to break down the oxalate into sodium carbonate/bicarbonate and aluminium trihydrate. This is pumped as a slurry with the bauxite residue to the disposal areas and handled within this contained system.

*Waste Acids*

Spent sulphuric and hydrochloric acids used in removal of scale and cleaning of process vessels are pumped to, and contained within heavy duty polyethylene lined solar evaporation ponds.

*Filter Cloths*

Other contaminated, or potentially contaminated wastes originating from the refinery, such as scale and used filter cloths, are disposed of directly into the contained bauxite residue disposal areas.

*Waste Oils, Lubricants, Solvents and Paints*

Waste lubricants, solvents, and paints are temporarily stored in a contained area prior to removal offsite by licensed contractors for either recycling (of lubricants) or treatment.

*Fibrous Insulation*

All fibrous materials are sealed in plastic bags and disposed of in prepared trenches in accordance with Health Regulations.

*Inert and Putrescible Waste*

General office and workforce waste is disposed of in a licensed sanitary landfill site at the refinery. The landfill site is located within the contained water management system (section 6.4.2) and the deposition of waste in this site is strictly controlled. Where possible, materials are separated at source and removed off-site with other bulk paper stored on-site for recycling.

*Sewage*

Refinery sewage is treated on-site, with treated effluent being disposed of into the refinery catchment lake for reuse in the refinery process.

*Scrap Metal*

All scrap metals are separated by alloy type, and are removed off-site by scrap metal merchants.

***Refinery Waste Management Commitments***

79. Continue with the philosophy of waste minimisation.

80. Promote the reuse or recycling of wastes where practicable.

81. Operate the refinery sanitary landfill site in a manner that protects the values of surface and groundwaters.

### 5.4.6 Noise Management

***Objective***

To comply with statutory requirements so that the amenity of nearby residents is protected from noise impacts resulting from refinery operations.

***Noise Management Strategy***

The closest noise sensitive premise is located over eight kilometres to the south of the refinery.

Worsley have undertaken a program of environmental noise assessment in conjunction with the consultant Sound and Vibration Technology Engineering to determine the audibility of the refinery at the nearest residences.

The environmental noise assessment has consisted of successive radial measurements out to five kilometres from the refinery, and noise monitoring at the three nearest residences.

Noise levels recorded at the residences do not indicate any abnormally high or sustained ambient noise and therefore does nor represent any significant contribution from the refinery of the three nearest residences. Ranges recorded are consistent with localised activities such as wind generated noise and noise from fauna. Night time L90 noise assessment at the three nearest residences between 28 and 40 dB(A). Noise assessment at the three residences indicated that refinery noise was not clearly audible, and hence a tonal penalty would not apply.

Radial noise managements take north, south, east and west of the refinery plant show noise levels to decay from 70 dB(A) at the refinery centre to below 35 dB(A) five kilometres from the refinery (Figure 27).

Expansion of the refinery will not see the introduction of any plant or processes which will contribute to greater noise output from the refinery. While an adequate buffer area is maintained surrounding the refinery (see Section 8) the impact of noise on nearby residents will remain negligible.

***Refinery Noise Management Commitments***

82. Conduct periodic acoustic assessment at nearest sensitive premises to the refinery to ensure continued compliance with statutory requirements.

### 5.4.7 Visual Impact

The refinery site is situated some 15 km north of the Coalfields Highway. From a short section of the Coalfields highway which traverses cleared agricultural land, some refinery plant is visible.

Successive raising of embankments of the residue disposal areas has the potential to make these areas visible from a distance.

The ERMP emphasised the reduction in visual impact of the project areas by keeping required clearing activities to a minimum. Specific to the residue disposal areas, Worsley have committed to promptly rehabilitate disposal areas by continuing to revegetate embankments and once decommissioned, revegetating the surface.

Worsley have also conducted a tree height survey throughout the refinery lease area to provide an indication of acceptable limits for final heights of the disposal areas. Residue areas will be kept below the height of the surrounding tree canopy.

All civil earthworks which take place throughout the lease area are revegetated where practicable.

## 5.5 GREENHOUSE GAS MANAGEMENT

### *Objective*

To reduce as much as practicable the net emission of greenhouse gases from project operations.

### *Significance of Impact*

The greenhouse effect is a natural phenomenon that keeps the Earth's surface within a temperature range necessary to sustain the current diversity and distribution of life. This effect is controlled by the amounts of certain gases (called greenhouse gases) in the atmosphere. The main anthropogenic source of greenhouse gases is from the burning of fossil fuels such as coal, oil or gas to produce carbon dioxide.

The increase in greenhouse gases in the atmosphere since the commencement of the industrial revolution has given rise to the speculation that the average temperature of the earth's atmosphere may rise, resulting in climate change.

The proposed expansion, while increasing the emission of carbon dioxide to the atmosphere from the burning of coal or natural gas, will result in a decrease in the unit rate of carbon dioxide per tonne of alumina produced. The choice of fuel to be used in association with the expansion will be determined in conjunction with of detailed feasibility studies.

### *Existing Environmental Conditions and Commitments*

Australia is a signatory to the United Nations Framework Convention on Climate Change which obliges Australia to take all practicable steps to abate greenhouse gas emissions. One of the major elements in the strategy to reduce greenhouse gas emissions has been the development of a program of cooperative agreements with industry. This program known as "The Greenhouse Challenge" seeks to ensure industry adopts the principles of continual improvement in energy and process efficiencies, greenhouse sink enhancement, and effective use of resources.

### *Greenhouse Gas Control Strategy*

The strategy aims to improve energy efficiency, decrease where practicable the generation of greenhouse gases, and maximise the development or preservation of new and existing greenhouse sinks respectively. Worsley will also participate in industry-wide approaches to reduce greenhouse emissions where practicable.

*Participation in Industry Commitments*

Worsley is a member of the Aluminium Development Council of Australia. The Council is among the first Australian industries to lodge a letter of intent with the Commonwealth Government to participate in The Greenhouse Challenge. As an aluminium industry, the Australian aluminium industry is recognised as the most energy efficient in the world, and has made substantial progress in reducing greenhouses gas

unit emissions. Worsley has contributed to that energy efficiency by reductions in specific unit energy consumption.

*Energy Efficiency*

Worsley have continued a program of unit energy improvement. This program has most significance at the refinery. Since refining operations began, specific energy consumption has decreased. Refinery expansion will result in a further decrease of 10% per unit of alumina produced.

*Rehabilitation and Reduced Burning*

Under the current rehabilitation strategy preliminary data suggests that due to rapid growth and assimilation of carbon dioxide in rehabilitated mining areas, the mine area will become a net greenhouse sink in 2009 (Coffey Partners, 1995).

Prior to clearing for mining operations or construction at the refinery, all merchantable timber is removed by CALM. Under the Agreement Act, Worsley pays the State compensation for forest clearing which is intended to be used for the re-afforestation of equivalent areas of land. Unmerchantable forest residue has, in the past, been stockpiled and burned thereby contributing to the production of greenhouse gases. Worsley will seek to minimise the amount of forest debris burned by returning as much forest debris as is practicable to rehabilitation areas (see section 5.2.4).

*Use Alternate Fuels with Lower Greenhouse Emissions*

Where practicable, Worsley will investigate the feasibility of alternative fuels with lower greenhouse emissions. The three calciners originally designed to be fired by fuel oil are now fired with natural gas. The fourth calciner installed in 1989 is gas fired, and the two additional units required for the project expansion will be fired by natural gas.

Expansion of the powerhouse capacity by the additional of a fourth gas or coal fired boiler is being investigated as part of plant feasibility.

*Halon Changeover*

Worsley have begun a program of changing over the ozone depleting halon fixed flooding fire extinguishing systems located throughout the operation. These systems are installed in the electrical distribution and computing centres.

*Greenhouse Gas Inventory*

Worsley commissioned the preparation of an inventory of greenhouse gas emissions from the bauxite/alumina project for this CER. This inventory (Table 15) describes the emissions arising from current operations of 1.75 million tonnes per annum. The majority of greenhouse emissions originate from the stationary fuel combustions sources, in particular the coal fired powerhouse, and to a lesser extent the gas fired calciners. Other sources included in the inventory have been emissions from fuel

combustion from the mobile vehicle fleet, fuel storage facilities, and land use changes associated with the operation.

The inventory has been prepared using the guidelines and protocols outlined in the National Greenhouse Gas Inventory Committee work books. The gases described include:

- carbon dioxide ($CO_2$)
- carbon monoxide (CO)
- methane ($CH_4$)
- nitrous oxide ($N_2O$)
- oxides of nitrogen ($NO_X$)
- non-methane volatile organic compounds (NMVOC)
- oxides of sulphur ($SO_X$)
- fluorocarbons (FC)

**Table 15: Greenhouse Gas Inventory for the Worsley Project, 1995.**

| Source | Emissions (Gg/annum) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_x$ | FC |
| Fuel combustion (stationary) | 1668 | 0.015 | N/A | 4.24 | 0.26 | 0 | 9.6 | 0 |
| Fugitive fuel emissions | 0 | 0 | 0 | 0 | 0 | 0.193 | 0 | 0 |
| Transport | 15 | 0.002 | 0.0004 | 0.31 | 0.15 | 0052 | 0.02 | trace |
| Biosphere | 43 | 0.232 | 0.003 | 0.06 | 4.06 | 0.448 | 0 | 0 |
| Industrial emissions and solvents | -9* | | | | | | | |
| Total emissions Global Warming Potential | 1718 | 0.248 | 0.0032 | 4.62 | 4.47 | 0.693 | 9.62 | trace |

*sink due to $CO_2$ assimilation

***Greenhouse Gas Management Commitments***

83. Preserve green house sinks on Joint Venturer-owned land.

84. Minimise burning of forest debris.

85. Remove all halon-fixed flooding fire extinguishing systems.

86. Reafforest an area of Joint Venturer-owned land equivalent to any sustained increase in the open area of the mine.

87. Investigate the potential to improve energy efficiency of calciners, power generation and steam rising facilities.

88. Investigate where practicable alternative fuel sources for lower greenhouse emissions.

## 5.6 IMPLICATIONS OF CLIMATE CHANGE

Predicted climate changes as a result of global warming are outlined in section 3.2. The main climate change fraction which is likely to have any affect on the Worsley Project is rainfall, in particular the amount received, and frequency and intensity of occurrence, and resultant runoff.

The main areas where changes in rainfall could have an affect at the refinery are in the plant water balance, and the water management system. However, under the current climate change scenarios (Mitchell *et al*, 1994) these changes would have no adverse effect on operations.

Water balance modelling indicates during the next 10 years some periodic shortfall in freshwater supply may occur (section 4.3.2). As residue storage areas increase in size (and therefore catchment area) water collected in these areas will satisfy the refinery demand and alleviate the need for large volumes of fresh make-up water. This would have no adverse affect on the supply of fresh water to the refinery. Modelling predicts the freshwater lake will continue to overflow each year.

Water management structures at the refinery such as residue disposal areas and pipehead dams, are designed to handle high intensity storm events. If the frequency of these events were to increase (from say 1 in 1000 years to even 1 in 50 years) as a result of climate change, this would have no impact on the function of these structures or the ability of these structures to contain storm water

Changes to the climate may affect the biodiversity in the eastern Darling Range forest and in rehabilitation. Higher rainfall would favour those species more adaptable to wetter conditions. These species may become more abundant at the expense of species with less tolerance for these conditions. Under drier conditions species more adaptable to less rainfall may become more dominant.

A decrease in rainfall would reduce aquifer recharge and alternative sources of water may be required to service the mining operation. An increase in rainfall would favour recharge of the aquifer systems.

The current stormwater management strategy may be required to be modified under increased rainfall and an increase in the frequency of summer storms. A change to the design criteria of stormwater containment sumps may be necessary to accommodate a possible increase in stormwater runoff.

Worsley will monitor the development of climate change investigations and incorporate findings into project planning and rehabilitation strategies.

# 6. SOCIAL ENVIRONMENT AND MANAGEMENT

This section updates information on the social environment of relevance to the proposal that was presented in detail in the draft ERMP and outlines Worsley's management response and commitments to mitigate impacts on local communities.

*Objective*

To reasonably assist local communities to manage social impacts arising from the construction and operational stages of Worsley's expansion.

## 6.1 COMMUNITY CONSULTATION

*Objective*

To ensure that the local community is adequately consulted in relation to the expansion and subsequent changes to the Worsley Project.

A thorough scoping of environmental issues early in the environmental assessment process is critical to the adequacy of the present environmental review. Worsley has conducted (and will continue during the public review period for this CER) an extensive community and Government agency consultation program. The aim of this program was to determine the environmental issues that are of potential concern to the community in order that those issues can be addressed adequately in this environmental review.

Worsley will also undertake an intensive consultation program during the public review of this CER and the construction phase of the project (details below).

### 6.1.1 Organisations and Individuals Consulted

Worsley has held discussions (often on more than one occasion) with the following organisations:

- Councillors and staff from the Shires of Harvey, Boddington and Dardanup and the City of Bunbury.
- Landowners in the vicinity of the bauxite mine.
- Local members of Parliament from the south west.
- Conservation Council Of Western Australia.
- Government agencies including the EPA; Department of Environmental Protection; CALM; Department of Resources Development; Commonwealth Department of Environment, Sports and Territories; Water Authority; Main Roads Department; Bunbury Port Authority; Westrail and Western Power.

These discussions provided a substantial amount of information on the potential environmental issues of concern to the local and broader community. The cooperation of these individuals and organisations is gratefully acknowledged.

### 6.1.2 General Community Consultation

In addition Worsley instituted an independent survey by Rearck Research (Rearck, 1995) involving face to face or telephone interviews of residents in the vicinity of the mine and the refinery. In particular, the sampling methodology of the survey ensured that most residents (if not all) close to the mine and refinery (for instance Worsley siding) were interviewed.

A focus group discussion with eight farmers near the Boddington mine was also held to obtain information on potential concerns. This discussion assisted with the construction of the survey.

In all 281 residents were surveyed.

The most prominent environmental issues of potential concern to those interviewed are described in Table 16 and cross referenced to the section where the issue is addressed.

**Table 16 : Environmental Issues Raised from Public Survey**

| Issue | CER Section |
|---|---|
| ***The bauxite mine and conveyor*** | |
| noise and vibrations from blasting | 5.2.5 and 5.2.6 |
| impact on the landscape | 5.2.10 |
| conveyor noise | 5.3.2 |
| forest clearing and rehabilitation | 5.2.1 and 5.2.2 |
| vehicle noise from the mine | 5.2.6 |
| impacts on water supply and quality | 5.2.5 |
| mine traffic | 5.2.4 |
| ***The refinery*** | |
| air pollution | 5.4.1 |
| water pollution | 5.4.2 |
| pollution (unspecified); | 5.4.1 and 5.4.2 |
| traffic | 6.3.4 |
| forest clearing | 5.5 |
| disposal of caustic residue | 5.4.2 and 5.4.3 |
| noise | 5.4.6 |

Those residents closest to the mine tended to have a higher level of concern and were more likely to feel they have been directly impacted by the operations at the mine.

Some residents in areas closest to the refinery felt that increased traffic had an impact on their area but other impacts such as noise, dust or odours were relatively insignificant.

The main unprompted environmental issue across all communities was forest clearing and reforestation.

The survey also revealed that almost 80% of those interviewed regarded Worsley's environmental record in a positive light; seeing Worsley as having performed well or very well in this regard. The remaining 20% had expressed no opinion or did not know.

Approximately 80% of respondents across all communities thought that Worsley should be able to expand its current operations. The majority of the remainder expressed no opinion.

During the public review period associated with the assessment of this CER, Worsley will institute an intensive consultation program which will involve:

- conducting a series of open days in the region to answer any queries from the public;
- meetings landowners near the bauxite mine;
- meetings with councillors and staff of local authorities in the vicinity of the project;
- providing information on the environmental aspects of the development to all of Worsley's workforce;
- widespread distribution of this CER; and
- dissemination of information through community newspapers in the region.

Once the expansion is underway, Worsley would expect to continue to liaise closely with local authorities and nearby residents that may be potentially affected by the expansion project.

Irrespective as to whether the expansion goes ahead, Worsley will maintain its current consultation program (section 1.2) which includes regular annual meetings with landowners near the mine as well as consultations with local communities as issues of interest arise.

## 6.2 BAUXITE MINE

The bauxite mine is located in the Shire of Boddington (Figure 2) in the south west corner of Western Australia and is part of the Peel Development Region. The surrounding area is primarily State Forest or agricultural land used for grazing and

crop production. Mining is a relatively recent industry in the area and now, together with agriculture forms the major cornerstone of the local economy.

The expansion of mining associated with the expansion of alumina production will not involve a construction workforce, but an increase of up to 55 persons in the mine operational workforce which is presently 120 persons.

Worsley is an owner operator and employs contractors for specialist or peak load work in the mining operation.

### 6.2.1 Community Structure and Employment

The estimated resident population of the Shire of Boddington (Table 17) was 1440 in June 1994 (Australian Bureau of Statistics, 1994) and is projected to grow to 1800 in the year 2000 (WA Planning Commission 1992). In 1981 the population of Boddington was 749 (Australian Bureau of Statistics, 1994) indicating that the Shire's population has almost doubled since this time. The age structure of Boddington Shire (Table 19) has changed since 1981 with a higher proportion of the population in the 20-54 year old age group.

The growth in population over the last decade has been primarily sustained by the establishment of the Boddington bauxite mine and the Boddington and Hedges gold mines. The percentage of persons in the workforce employed in the mining industry (Table 18) was 50.9% in 1991 demonstrating that this industry is the single largest employer in the Shire. The agricultural and manufacturing industries employ a total of 31.2% of the workforce.

**Table 17: Estimated Resident Population and Population Projections**

| Local Authority | Estimated Resident Population[7] | | | | Population Projections[8] | | |
|---|---|---|---|---|---|---|---|
| | 1991 | 1993 | 1994 | growth 1991-1994 | 1996 | 2001 | 2006 |
| Boddington | 1,341 | 1429 | 1440 | 7.4% | 1,600 | 1,800 | 2,000 |
| Bunbury | 27,305 | 27,812 | 27,917 | 2.2% | 28,100 | 29,300 | 30,750 |
| Collie | 9,842 | 9,489 | 9,441 | -4.1% | 9,200 | 9,600 | 10,000 |
| Dardanup | 5,458 | 5,967 | 6,181 | 13.3% | 6,500 | 7,000 | 7,500 |
| Harvey | 13,097 | 14,335 | 14,610 | 11.6% | 15,300 | 17,100 | 18,800 |

The unemployment rate (not seasonably adjusted) in the Shire for the June quarter from 1990 to 1995 varied between 1.8 and 4.2%, with a rate of 3.2% for 1995

[7] *Source:* Australian Bureau of Statistics

[8] *Source*: Western Australian Planning Commission (Boddington population are based on projections from June 1992, before the estimated resident population figures became available from the 1991 census).

(Department of Employment, Education and Training pers. comm.). This compares with a rate of 7.2% for Western Australia in the same quarter of 1995.

**Table 18: Industry Composition of Workforce by Local Authority Area***

| INDUSTRY | BODDINGTON | | BUNBURY | | COLLIE | | DARDANUP | | HARVEY | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Prop (%) | No. | Prop (%) | No. | Prop (%) | No. | Prop (%) | No. | Prop (%) |
| Agric, forestry, fish & hunt | 102 | 13.5 | 147 | 1.4 | 76 | 2.1 | 243 | 10.8 | 633 | 12.8 |
| Mining | 385 | 50.9 | 474 | 4.6 | 625 | 17.5 | 111 | 4.9 | 276 | 5.6 |
| Manufacturing | 6 | 0.8 | 1464 | 14.1 | 129 | 3.6 | 355 | 15.7 | 912 | 18.4 |
| Electricity, gas & water | 0 | 0.0 | 255 | 2.5 | 432 | 12.1 | 79 | 3.5 | 126 | 2.5 |
| Construction | 30 | 4.0 | 764 | 7.4 | 85 | 2.4 | 180 | 8.0 | 324 | 6.5 |
| Wholesale & retail trade | 33 | 4.4 | 2173 | 21.0 | 429 | 12.0 | 396 | 17.5 | 704 | 14.2 |
| Transport & storage | 9 | 1.2 | 484 | 4.7 | 93 | 2.6 | 99 | 4.4 | 155 | 3.1 |
| Communication | 0 | 0.0 | 112 | 1.1 | 6 | 0.2 | 31 | 1.4 | 38 | 0.8 |
| Finance, property & busns serv. | 56 | 7.4 | 827 | 8.0 | 646 | 18.1 | 121 | 5.4 | 264 | 5.3 |
| Public admin & defence | 9 | 1.2 | 314 | 3.0 | 85 | 2.4 | 76 | 3.4 | 140 | 2.8 |
| Community services | 62 | 8.2 | 1841 | 17.8 | 516 | 14.5 | 308 | 13.6 | 788 | 15.9 |
| Recrtn, personal & other serv | 28 | 3.7 | 813 | 7.8 | 198 | 5.5 | 116 | 5.1 | 211 | 4.3 |
| Not classifiable | 0 | 0.0 | 36 | 0.3 | 0 | 0.0 | 12 | 0.5 | 18 | 0.4 |
| Not stated | 36 | 4.8 | 662 | 6.4 | 250 | 7.0 | 133 | 5.9 | 374 | 7.5 |
| **TOTAL** | **756** | **100** | **10366** | **100** | **3570** | **100** | **2260** | **100** | **4963** | **100** |

**Source*: *Australian Bureau of Statistics*

### *Impact Assessment*

In summary, the Shire of Boddington has experienced a large increase in population over the last decade and has a relatively youthful population and a low level of unemployment.

If current employment patterns in gold mining activities in the area are maintained an increase of up to 7% in the workforce of the Shire may result from the proposed expansion of the mine. If such an increase in the Shire workforce does occur a similar increase in the population may be anticipated given the low unemployment rate in the Shire.

The significance of these increases with respect to the infrastructure of the Shire of Boddington is discussed under each of the topics below.

### 6.2.2 Residential Land and Accommodation

In 1993 there were approximately 344 dwellings (including caravans in parks) in the Boddington area (Shire of Boddington, 1995). Worsley has recognised the need to

address impacts on Boddington given the size of the original bauxite mine workforce and the small population of Boddington at the time. Prior to and following the commencement of mining activities, Worsley has made contributions (totalling $4.08 million) to increase the available accommodation and upgrade the water supply (section 6.4) in Boddington.

**Table 19: Age Structure of the Shire of Boddington Population***

| Age | Persons | | Proportion (%) | |
|---|---|---|---|---|
| | 1981 | 1994 | 1981 | 1994 |
| 0-4 | 69 | 143 | 9.2 | 9.9 |
| 5-9 | 77 | 121 | 10.3 | 8.4 |
| 10-14 | 75 | 99 | 10.0 | 6.9 |
| 15-19 | 50 | 90 | 6.7 | 6.2 |
| 20-24 | 70 | 103 | 9.3 | 7.2 |
| 25-29 | 64 | 150 | 8.5 | 10.4 |
| 30-34 | 55 | 162 | 7.3 | 11.2 |
| 35-39 | 59 | 139 | 7.9 | 9.6 |
| 40-44 | 41 | 122 | 5.5 | 8.5 |
| 45-49 | 39 | 93 | 5.2 | 6.5 |
| 50-54 | 30 | 73 | 4.0 | 5.1 |
| 55-59 | 35 | 54 | 4.7 | 3.8 |
| 60-64 | 18 | 23 | 2.4 | 1.6 |
| 65 -69 | 25 | 23 | 3.3 | 1.6 |
| 70 and over | 42 | 45 | 5.6 | 3.1 |
| **Total** | **749** | **1440** | **100** | **100** |

**Source: Australian Bureau of Statistics*

The Shire of Boddington is currently implementing a completely revised Town Planning Scheme which provides for residential land. The Shire estimates (Shire of Boddington, pers. comm.) that there are approximately 20 private residential lots presently available and a further 30 to 60 lots potentially available (residential land not yet subdivided) in the town.

The majority of the bauxite mine workforce (69%) resides in the Shire of Boddington with the remainder residing in Mandurah (7.8%), Williams (7.8%), Quindanning (5.5%), Perth (4.7%), Dwellingup (2.3%), Darkin (1.6%) and Wandering (1.6%). A similar pattern of habitation is anticipated for the expanded workforce at the bauxite mine.

***Impact Assessment and Management***

Up to 38 of the additional workforce may choose to live in the Shire of Boddington. If required Worsley may contract up to an additional 10 units of rental accommodation through Boddington Housing Pty Ltd.

It is anticipated that the additional workforce can be readily accommodated given the stock of residential land that is available or potentially available.

***Accommodation Commitments***

89.If required construct new Joint Venturer-owned accommodation in the town of Boddington.

### 6.2.3 Community Services and Facilities

Boddington, while not having a large population has very good facilities. The commercial centre includes a supermarket, hairdresser, real estate agent, clothing shops, restaurant and others. The centre also provides banking and post office facilities.

Community health is served by a doctor and child health centre as well as a district hospital and ambulance service. Other emergency services include Police and Country Fire Brigade.

The Boddington township has child care facilities and a district junior high school catering for students from pre-school to year 10. The closest senior high school is in Pinjarra approximately 80 km away, but Narrogin Senior High School is also used by the community. A variety of recreation facilities are also available in the area including a swimming pool, tennis courts, bowling green and golf course.

***Impact Assessment and Management***

Since bauxite and gold mining activities began Worsley has contributed to the provision of community facilities at each stage of mining development by direct contributions totalling $4.08 million to sporting, recreation, education, health, Shire administration facilities, roads and water supply (section 6.4).

In addition Worsley also maintains significant ongoing support (section 6.4) to the Shire and community by contributions, totalling so far $282,000 to:

- Community groups through the Worsley Alumina Community Involvement Committee (WACIC);
- Community safety and health projects through the Community Aid Through Safety (CATS); and
- Shire infrastructure projects from the surplus from management of the Boddington Housing Pty Ltd (BHPL).

Some of the community infrastructure projects partially funded under these schemes include the Boddington swimming pool, infant centre, and streetscaping.

Given the level of community facilities and the ongoing assistance provided by Worsley the impact of the increased mining operations should be minimal.

### 6.2.4 Road/Traffic

**Objective**

To reduce as much as practicable the impacts of road traffic resulting from the expansion of mining.

The following are the three major road links in the Boddington area, all of which are in reasonable condition:

- Collie/Boddington Road;
- Pinjarra/Williams Road; and
- Harvey/Quindanning/Boddington.

There is no rail transport available but Westrail operate a Perth to Albany bus service which stops in Boddington.

Traffic counts[9] are available from September/October 1994 for several of the road links around the minesite (Main Roads, Narrogin pers. comm.). These include:

- Pinjarra/Williams Road, immediately west of Marradong Junction - 436 vehicles/day.
- Pinjarra/Williams Road, immediately east of Marradong Junction - 357 vehicles/day.
- Bannister/Marradong Road, close to Albany Highway - 286 vehicles/day.
- Collie/Williams Road, 60 km from Collie - 99 vehicles/day.

These roads are all sealed and constructed to a capacity well in excess of the volumes indicated by the above traffic counts (Main Roads, Narrogin pers. comm.).

***Impact Assessment and Management***

In the past Worsley has contributed to the construction of roads and the maintenance of the road system in the Shire. Worsley contributes (section 6.5) to such works through funds gifted to the Shire from surpluses generated from the management of rental housing.

Based on the assumption that the additional mine workforce (up to 55) will have a similar residential distribution to the existing workforce, and an average of two to three people per car, the increase in vehicles on the Pinjarra/Williams Road is expected to be small (approximately five vehicles). An increase of approximately 15-20 mine workforce vehicles would be expected on Bannister/Marradong Road between Boddington and the minesite (69% of the existing mine workforce resides in Boddington with 14% commuting to Perth or Mandurah).

[9]Traffic counts refer to total vehicles per day in both directions combined.

The increased mine traffic adds only marginally to the existing volumes of traffic on these roads.

Some concern has been expressed by some residents in the independent survey carried out by Reark (section 6.1) about vehicular traffic from the mine. The cause of this concern more than likely relates to changeover traffic at the end of a mining operation shift at night.

The number of workforce vehicles presently leaving the mine at approximately midnight at the end of the afternoon shift, is estimated to average 10 (assuming two persons per vehicle). Depending on the mining programme and shift and rostering arrangements determined for the expansion, the number of vehicle movements at night may double to 20.

While these traffic volumes are small, Worsley is aware of the concern of some residents and will, as far as practicable, take into account these aspects when considering shift arrangements for the expansion.

***Road/Traffic Commitment***

90. Take into account as far as practicable the concerns of residents when considering shift arrangements for expanded mine activities.

## 6.3 REFINERY AND OVERLAND CONVEYOR

The overland conveyor traverses mainly State Forest and crosses farming land near the Murray and Hotham Rivers for only a small proportion of its length. The refinery is surrounded by State Forest with the nearest residence approximately eight kilometres away. The Worsley siding with a very small residential population is 10 km from the refinery and the closest town is Allanson 15 km away.

The refinery is located on the boundary between the Shires of Collie and Harvey and is within commuting distance of the population centres of Collie, Harvey, Bunbury, Australind and Dardanup in the south west of Western Australia (Figure 2).

During construction the workforce is estimated to increase to a peak of up to 700 in the two year construction period. Depending on the technology employed in the refinery, the operational workforce is expected to increase by 100 from the present 800 to 900.

Worsley anticipates that many of the required skills of the workforce will be available locally and the need to import skills should be minimal.

### 6.3.1 Community Structure and Employment

The estimated residential populations of local authorities which may be affected by the proposed expansion of the refinery are presented in Table 17. The City of Bunbury is the largest population centre with an estimated resident population of 27,917 and the

Shire of Dardanup the lowest with a population of 6,181 (Australian Bureau of Statistics, 1995).

Strong population growth is anticipated in Harvey and Dardanup with moderate growth in Bunbury and Collie (Western Australian Planning Commission, 1995 pers.comm). The population growth of Collie is sensitive to the expansion of the coal mining and power generation industries.

The employment structure of the workforce (Table 18) for each of the local authorities varies considerably, with mining and power generation (total of 29.7%) being the predominant employers in Collie, and with manufacturing (18.4%) and agriculture (12.8%) being predominant in the traditional agricultural centres of Harvey and Dardanup.

A comparison of the 1986 and 1991 Census of Population and Housing showed that the proportion of the workforce employed in agriculture and manufacturing declined in Harvey and Dardanup in this period. Bunbury, being the regional administrative and commercial centre of the South West Region has large wholesale/retail, manufacturing and community service sectors (Table 18).

The 1995 June quarter unemployment rates for the Bunbury, Collie, Harvey and Dardanup local authorities were 7.1%, 7.6%, 5.9% and 3.6% respectively. (Department of Employment, Education and Training, pers. comm).

***Impact Assessment***

The increased operational workforce will result at best in a marginal increase in population given the large workforce that is potentially available in the region. The construction workforce is likely to be of more significance, principally from the extra demand placed on short term accommodation which is addressed in section 6.3.2.

Worsley considers a local workforce with the appropriate skills from the region will facilitate the management of social impacts from workforce increases.

### 6.3.2 Residential Land and Accommodation

Information gained from the Shires of Collie, Dardanup and Harvey and the City of Bunbury (Table 20) indicates that there is no shortage of available or potentially available land for housing.

**Table 20: Residential Land Potentially Available**

| Location | Available Blocks | Potentially Available Blocks (not Sub-Divided) |
|---|---|---|
| Bunbury | 3500 subdivided or partly subdivided | 1400 |
| Collie | 200-300 | 1179 |
| Dardanup | 60 - 70 | 2,000 plus 2,000 in 4-5 years |
| Harvey | 1300 plus 2,000 in 5-10 years | 7,000 |

Approximately 960 caravan sites are available in the area with an average occupancy rate of about 40% and 610 hotel/motel/guesthouse rooms with an average occupancy rate of about 48% (Western Australian Tourism Commission, 1994). Assuming these rates of occupancy are maintained 576 caravan sites and 317 hotel/motel/guest house rooms are normally available

Permanent rental accommodation consisting of houses and units is limited in Bunbury, Eaten and Australia. Discussions with local estate agents indicates there may be little accommodation available, with an average of 8-10 units and 8-10 houses registered with the larger estate agents as available or becoming available in these areas at any given time.

Rents in these areas range from $80 to $125 per week for units and $100 to $180 per week for houses.

The vacancy rate for private rental property in Collie is normally in the vicinity of 15% (Southern Districts Real Estate, pers. comm.) which corresponds to approximately 70 rental properties. Presently a construction camp for the Collie Power Station is being constructed five kilometres from Collie adjoining the Collie Power Station. This camp may provide opportunities for accommodation of the refinery construction workforce. Accommodation should be more readily available in Collie depending on the timing of the construction of the Collie Power Station and other major developments in the region.

***Impact Assessment and Management***

Worsley's refinery workforce resides predominantly in towns on the coastal plain (Table 21) with the majority of the workforce in the City of Bunbury (34.7%) and Shire of Harvey (30.6% - predominantly Australia). Approximately 13.8% and 14.6% of the workforce resides in the Shires of Collie and Dardanup (Eaton 11%) respectively.

A similar pattern of habitation is anticipated for any additional refinery operational workforce with the majority residing in the Bunbury/Australind/Eaton area. The increase of 100 in the permanent workforce should be readily accommodated in the region.

The following modes of temporary accommodation for construction workforce are potentially available in the region.

- private rental accommodation;
- caravan parks;
- hotel/motel/guesthouse accommodation;
- private single men's quarters; and
- construction camps.

**Table 21: Residential Location of Refinery Workforce**

| Local Authority | Town/City | Workforce Population | | Percent of Workforce | |
|---|---|---|---|---|---|
| | | | Total | | Total |
| Bunbury | Bunbury | | 270 | | 34.7% |
| Harvey | Australind | 181 | | 23.3% | |
| | Others | 57 | | 7.3% | |
| | **Total** | | 238 | | 30.6% |
| Collie | All | | 107 | | 13.8% |
| Dardanup | Eaton | 82 | | 10.6% | |
| | Others | 32 | | 4.1% | |
| | **Total** | | 114 | | 14.6% |
| Capel | All | | 36 | | 4.6% |
| Donnybrook | All | | 7 | | 0.9% |
| Busselton | All | | 3 | | 0.4% |
| Waroona | Waroona | | 1 | | 0.1% |
| Boyup Brook | Wilga | | 2 | | 0.3% |
| **Total** | | | **778** | | **100%** |

*Source*: Worsley Alumina Pty Ltd

Worsley will provide construction camp accommodation on its land near the refinery if local accommodation is not available. However, Worsley anticipates that the construction workforce will prefer to make their own accommodation arrangements and live in nearby towns.

It is quite likely the construction workforce that comes into the region will prefer to take up temporary accommodation as close as possible to the refinery. This being the case, Collie might be the preferred accommodation location, particularly as it would appear that Collie has more temporary accommodation available.

The availability of accommodation for the construction workforce will be highly dependent on the timing of other major developments in the region. Worsley will continue to actively petition the Government agencies to address the problems of accommodation that might arise if other major developments occur in the region.

Worsley will fully support and cooperate with an appropriate Government consultation and coordination mechanism which involves the local authorities, Government agencies and proponents of major projects in the region, to address issues of construction workforce accommodation in the region.

***Accommodation Commitments***

91. Participate in any appropriate Government coordinated consultative forum to address issues of workforce accommodation.

92. Provide construction camp accommodation near the refinery if alternate accommodation is unavailable in the region.

### 6.3.3 Community Services and Facilities

Bunbury is a large regional centre with primary, secondary and tertiary educational institutions including the Bunbury Campus of Edith Cowan University and the South West College of Technical and Further Education.

Bunbury has a large central business district with restaurants, hotels and a large variety of shops. The City is also able to cater for medical needs with two hospitals, doctors, medical centres, dentists and nursing homes.

The Shire of Harvey has many facilities including schools (12 primary and two high schools) and a TAFE centre. Hospitals are located in Harvey and Yarloop and the community has access to doctors, dentists and emergency services including police, ambulance and country fire brigades.

The Shire has two large recreation centres, one at Harvey and one at Australind along with many other recreation facilities.

The Shire of Collie also has many facilities including a district hospital, schools, a TAFE centre, police, ambulance and medical centres. The commercial centre has a variety of shops and recreation facilities include a swimming pool, bowls and a golf course as well as provision for many other sports.

Dardanup is a smaller Shire with an estimated population in 1994 of 6,181 compared with 9,441 in Collie; 14,610 in Harvey and 27,917 in Bunbury, consequently Dardanup does not have the same facilities as the larger local authorities. However, the local community has access to excellent facilities which are relatively close in Bunbury.

***Impact Assessment***

Facilities in the Shires of Harvey, Dardanup and Collie and in the City of Bunbury are generally very good and are expected to be able to adequately cater for any increase in the refinery workforce.

### 6.3.4 Rail

***Objective***

To reduce as far as practicable the impacts of road and rail traffic resulting from the expansion of refinery operations.

The refinery is serviced by a railway, which transports raw materials to the refinery and alumina product to the Bunbury Inner Harbour for export. The railway is an extension of the main Bunbury to Collie railway which handles predominantly bulk cargoes of alumina and coal. Westrail manages the rail network and considers that the system is adequate for current demands (DPUD, 1993). Currently 30 trains per week deliver coal, caustic and lime to the refinery and with the expansion the frequency may increase up to 65 per week depending on the size of the trains.

Early advice from Westrail suggests that the additional train movements are unlikely to have adverse environmental implications. However, Worsley acknowledges that further investigation of environmental impact may be warranted by Westrail and would co-operate as far as practicable with such an investigation. Westrail has advised that no additional rail infrastructure will be required (Westrail pers. comm.).

Worsley anticipates that Westrail will address any environmental impacts that may arise from changes in train movements.

### 6.3.5 Roads

*Objective*

To reduce as far as practicable the impacts of road and rail traffic resulting from the expansion of refinery operations.

The main Bunbury to Collie Road (Coalfields Road) is 11 km to the south of the refinery and joins the South West Highway at the base of the Darling Scarp at Roelands.

Primary access to the Refinery is via Coalfields Road (Roelands-Lake King Road). The road is a district distributor road, servicing the bauxite mine of Worsley and coal mining at Collie, giving both access to Bunbury and Perth. The road also services the timber industry and agricultural areas east of Collie. The section of Coalfields Road between South Western Highway and Collie is an approved cartage route for trucks up to B-double configuration and is used mainly for general freight, coal and forest products.

Traffic counts are available from the Main Roads for the following locations:

- Coalfield Road* (August 1991) - immediately east of South West Highway - 2020 vehicles average per 12 hour (7am to 7pm).

- Coalfield Road (May 1994) - immediately west of the Worsley Refinery turnoff - 2324 vehicles average per week day.

- Coalfield Road (May 1994) - immediately west of Collie town centre - 4519 vehicles average per week day. This count would probably include a significant amount of local traffic.

The current truck traffic is around 11% of the average daily traffic (MRWA counts, August 1991).

The existing Coalfields Road is a two-lane, two-way road with passing lanes at certain locations. Road authorities have recognised that the condition of the road and volume of traffic warrant progressive upgrading of the road. Where volumes exceed 2000

*Traffic counts refer to a 12 hour period between 7am and 7pm and are combined east/westbound data.

vehicles per day a nine metre seal with passing lanes is suggested. Where traffic exceeds 4500 vehicles per day, the development of a dual carriage-way is suggested (MRWA, 1995).

Accident statistics supplied by Main Roads WA for Coalfields Road between South Western Highway and the Collie town-site, indicate that in the three year period from 1 September 1992 to 31 August 1995, 74 accidents have occurred. These include one fatal and 21 hospital or medical treatment accidents. The majority have occurred during the dry conditions in daylight hours and have involved vehicles hitting an object or another vehicle. A considerable number appear to relate to intersection movements.

On the basis of an average daily traffic flow along that section of the road, of about 2,500 vehicles, the road has an accident rate of about 0.84 accidents per million vehicle kilometres travelled. This rate is comparable with the average accident rate for the South West and Peel regions of 0.89 accidents per million vehicle kilometre travelled (MRWA, 1995).

Secondary access to the Worsley Refinery is via Mornington Road from Harvey and Collie. Mornington Road provides a short cut from Harvey, reducing the travel distance by approximately 24 kilometres, but at a lower speed. Mornington Road from the South Western Highway, south of Harvey, intersects the access road to the refinery north of Worsley siding.

Mornington Road is unsealed for approximately 17 km west of the Worsley turnoff and sealed between Collie and Worsley and for 6 km from the Southwest Highway. At the time of writing this report the condition of the western section of Mornington Road was described as poor to average (Shire of Harvey, pers comm).

Mornington Road is a local road, carrying relatively low volumes of traffic. The following traffic counts are available for Mornington Road:

- Immediately east of South West Highway (MRWA, pers. comm.) - 202 vehicles per 12 hour total (7am to 7pm).

- Immediately west of the Worsley turnoff (Shire of Collie, pers comm) - 136 vehicles per day average. This survey was conducted over a 20 day period from 6-26 April 1995

The section of Mornington Road immediately east of South Western Highway is also used by trucks carting forest products at a frequency of about 10 trucks per day (DPUD, 1992). The road services primarily a local function with the heavy transport trucks usually taking the higher standard distributor roads nearest to their origin and destination (DPUD, 1992).

Accident statistics provided by Main Roads WA for Mornington Road between South Western Highway and Collie for the three year period 1 September 1992 to 31 August 1995 show a total of 16 accidents. The majority of these accidents occurred in dry conditions during daylight hours and involved the vehicles striking other objects.

Whilst there were no fatal accidents, the road does have an accident rate of 2.91 accidents per million vehicle kilometres travelled.

***Future Roadworks***

Both the Bunbury-Wellington Region Plan (DPUD, 1993) and the Roads 2020 Regional Road Development Strategy - South West and Peel Region (MRWA, 1995) acknowledge the need to upgrade Coalfields Road progressively to a dual carriageway between South Western Highway and Collie.

Officers from Main Roads WA Bunbury office indicate that reconstruction and upgrading works will commence in 1996 with the reconstruction of a priority six kilometre section.

Proposals to upgrade Coalfields Road will improve the alignment and provide a safer road with reduced travel times.

The current traffic volumes and accident rate on Mornington Road suggest that for maintenance and social reasons, consideration by Authorities could be given to upgrading the road. The Roads 2020 Regional Road Development Strategy - South West and Peel Region (MRWA, 1995) acknowledges this situation, but the proposal is one of a number subject to further review and appears unlikely to be considered in the short-term.

Worsley will participate in any Government coordinated working party to investigate and address issues of road safety and the upgrading of Mornington Road arising from the existing use and cumulative major construction projects in the region.

***Impact Assessment and Management***

The extensions to the Worsley Refinery will generate additional traffic in both the short and longer term. In the short term it can be expected that a construction workforce of up to a peak of 700 will be required over the two year construction period. An additional operating workforce of up to 100 is likely to be required.

To assess the impact on local traffic, it is assumed that the additional operational workforce will have a similar residential distribution to the existing workforce:

- 79% in the coastal area (principally Australind, Bunbury, Eaton and Dardanup)
- 14% in Collie; and
- 7% in Harvey.

It is not expected that there will be major public transport services available for workers to access the refinery, particularly during the construction period. It has been assumed that 90% of the workforce will arrive by car. Worsley's workforce practises car pooling, and occupancy rates of two to three persons per vehicle can be expected.

On any one day, it is also assumed that approximately 50% of the total refinery workforce is working at the refinery site, and they either work days (7.30am - 4.00pm) or shifts (7am to 7pm and 7pm to 7am).

Given these operational times, it is likely that the peak period for traffic movement, with respect to the operational workforce, will be in the morning between 6.30am and 7.30am.

Because of the uncertainty in being able to establish the accommodation pattern and shift operations of the construction workforce it is difficult to predict the impact on local traffic.

The number of extra vehicles using the Coalfields or Mornington Roads to the Refinery, will depend on the location of temporary accommodation and the source of construction materials and equipment. Given the likelihood of short term accommodation being available in Collie a substantial proportion of the construction workforce requiring accommodation may locate in this area.

It is therefore assumed that a construction workforce, will in the main, originate in equal proportion from either the Collie or Bunbury area and use Coalfields Road to access the site and with only a small proportion using Mornington Road.

Truck movements involving the delivery of raw materials such as flocculent and acids to the refinery are likely to increase from a current four per week to about eight per week. In respect of truck movements, Worsley will ensure that contractors are made aware that they are required to comply with appropriate noise standards.

The likely increases in traffic on the access roads are summarised in Table 22.

Based on the current pattern of accommodation of the permanent refinery workforce, the increase in traffic on Mornington Road and Coalfields Road between South Western Highway and the Refinery is expected to be minimal at about four vehicles per day and 40 vehicles per day respectively.

**Table 22: Traffic Analysis in Coalfields Road and Mornington Road (daily flows)**

| Road | Estimated Current Traffic | | Expected Increase In Traffic | | | |
|---|---|---|---|---|---|---|
| | | | Operational | | Construction | |
| | Average weekly daily traffic | Trucks | Average daily traffic | Trucks | Average daily traffic | Trucks |
| Mornington Road | 136 | 15 | 2 - 4 | 0 | 6 - 10 | 0 |
| Coalfields Road | 2324 | 260 | 26 - 40 | 1 | 188 - 252 | 21 |

The construction workforce at its peak is likely to generate approximately 188 - 252 additional vehicle movements per day (to and from the site). The magnitude of the permanent increase in traffic generated by the expansion is considered to be minimal with respect to the existing base traffic.

While the capacity of Coalfields Road is not expected to be exceeded, Main Roads have indicated that safety issues associated with the condition of the road system in the area require consideration.

The issue of safety has also arisen with respect to Mornington Road and the Shire of Harvey has indicated that upgrading works need to be addressed. The area of prime concern being an increase in traffic movement along Mornington Road primarily during construction.

Worsley recognises the Shire of Harvey's concern with regard to the impact of additional traffic on the surface of the unsealed section of Mornington Road, and will liaise closely with the Shire on this matter, prior to and during construction. The possible impact of construction traffic, workforce or materials and equipment transport, can be managed through the imposition of contractual conditions on the Contractors, requiring the use of Coalfields Road only, as access to the site. The Shire may also restrict the size of heavy vehicles using Mornington Road.

The up-grading of Coalfields Road proposed by Main Roads WA will increase its attraction to road users as the favoured route to the refinery. In the interim period between the refinery expansion and the up-grading works being complete, the impact of peak movements at the intersection of the Refinery access road and Coalfields Road can be monitored.

It is considered that traffic safety issues would mainly arise during the construction phase. The most likely area of concern will be the unsignalled T-intersection to the Refinery on Coalfields Road during the peak morning period.

Traffic counts for the intersection are not available but turning movements can be estimated from the known through movements and traffic origin/destination. The estimated current and future turning movements at the morning peak hour are shown in Figure 28.

A capacity check of the intersection involving the construction traffic reveals that there is adequate capacity to accommodate the additional traffic. There will be minimal delay to vehicles turning right. The current intersection layout provides a left turn lane and a widened passing lane for traffic turning right on Coalfields Road and is considered to be adequate.

In order to avoid congestion at this intersection during that period the start times can be staggered for the construction workforce and the normal 12 hour shift changeover or the commencement of the normal day work for the operational workforce.

It is important, however to recognise that there are other major construction projects in the region. For example, the Collie Power Station development will place

substantial demands on the road system. Therefore, issues of safety and up-grading requirements for the road network cannot be attributed solely to Worsley's expansion. There is however, a clear need for these issues to be addressed. Worsley believes that they are best addressed through a working party of Local Government authorities, relevant Government agencies and the proponents of major projects in the region.

***Road Traffic Commitments***

93. Liaise with the Shire of Harvey, prior to and during the construction phase of the project, on the impact of construction traffic on Mornington Road.

94. Require contractors to access the Worsley Refinery via the Coalfields and Gestaldo Roads with vehicular traffic of 12 tonnes or more.

95. Participate in a Government coordinated working party to investigate and address issues of road safety, and the upgrading of Mornington Road arising from the existing use and major regional construction projects.

96. If required, stagger start and finish times of construction and operations workforce shifts at the refinery.

## 6.4 COMMUNITY SUPPORT BY WORSLEY

Since commencement, Worsley has provided substantial support to all of the communities in which it operates.

Through a structured and well defined community support program including the Worsley Alumina Community Involvement Committee, Community Assistance Through Safety scheme and a company sponsorship program, Worsley contributes to a wide range of facilities and services in the local community.

Fundamental to all initiatives are the areas of youth, education, sports development, environmental management, health and safety.

For the bauxite mining operations, support is focussed directly in the Boddington area. Due to the well established infrastructure of communities in proximity of the refinery operations, however, community support and sponsorship is allocated across the regional boundaries of Collie, Bunbury, Harvey and surrounding areas.

Community support at Worsley is achieved not only through direct financial assistance, but also by the employees, themselves. Worsley employees provide a number of volunteer community services such as guest speakers for schools and local groups, represent south west industry at national and international events, conduct site tours for schools, universities, and media and special interest groups with advice on career development opportunities. These functions are facilitated by a full-time community relations officer.

Table 23 outlines major community support initiatives by Worsley since the commencement of operations.

**Table 23: Summary of Community Support by Worsley.**

| Locality | Timing | Infrastructure/Support | Contribution ($) |
|---|---|---|---|
| Boddington | Pre mining | Water supply pipeline | 3,090,000 |
| | | Establishment of caravan park | 80,000 |
| | | Rental housing | 1,010,000 |
| | | Access road | 1,469,000 |
| | Post mining | Sporting and recreation facilities | 830,000 |
| | | Education and health facilities and water supply | 1,790,000 |
| | | Shire administration facilities and roads | 1,440,000 |
| | | Rental housing | 3,097,000 |
| | | Water supply dams | 434,000 |
| | Ongoing | Worsley Alumina Community Involvement Committee (WACIC) - Allocation by committee of Worsley employees to community groups | 52,000 |
| | | Community Aid Through Safety (CATS) - awards to community health and safety projects | 165,000 |
| | | Boddington Housing Pty Ltd (BHPL) - surplus from rental housing management gifted to the Shire for infrastructure projects for example swimming pool, infant centre, street scaping | 230,000 |
| Bunbury | Since 1983 | Bunbury Entertainment Centre | 100,000 |
| Collie | Since 1983 | Access roads | 2,130,000 |
| | | Collie airstrip lights | 3,000 |
| | | Bibbulum track project | 20,000 |
| Harvey | Since 1983 | Leschenault Aquatic Centre | 30,000 |
| Total | Since 1983 | | 15,970,000 |

### *Community Support Commitment*

97. Subject to periodic review, continue existing programs to support community groups, infrastructure and services.

## 6.5 MAINTENANCE OF SEPARATION DISTANCES FROM SENSITIVE AREAS

### *Objective*

To maintain appropriate separation distances between project operations and sensitive areas in conjunction with relevant planning authorities.

### *Potential Significance of Impact and Management*

Activities associated with mining and refinery operations have the potential to affect the amenity of residences, should they be located close to Worsley's project operations.

The refinery site is relatively isolated from residences and is surrounded by State Forest. All private land between the refinery and the nearest residence (over eight kilometres from the refinery) is owned by the Worsley Joint Venturers (see Figure 20). Mining activities at the Boddington bauxite mine are located closer to residences, and may move closer to residential areas as mining progresses to the north from Saddleback.

Should land use change from State Forest or rural land in the future, project operations may potentially impact more on the amenity of residences should any choose to locate closer to the Worsley operations.

To maintain a buffer area around project operations, Worsley will monitor planning proposals for all areas adjacent to project operational areas, and maintain close liaison with State and local government to provide advice on implementation of planning proposals or regional planning strategies. Provision of Worsley's operational development plans to relevant agencies will ensure project development will be taken into account in the preparation of regional planning strategies.

***Separation Distance Commitments***

98. Retain Joint Venturer ownership of land within the buffer areas

99. Pursue if required retention or establishment of buffer areas surrounding project locations through local town planning schemes and in consultation with the State.

## 6.6 HERITAGE

In accordance with the *Heritage of Western Australia Act 1990*, Consultants (Martinek, 1995) have, on behalf of the Shire of Boddington, prepared an inventory of heritage places for the area in 1994 in association with the Peel Heritage Inventory Group. The following places in or adjoining the PBA were identified as having cultural heritage significance and have been recommended for inclusion in the official municipal inventory.

- Dilyan's Grave;
  The grave has been memorialised by the Royal Western Australian Historical Society and the Boddington Shire Council to commemorate Dilyan, who accompanied Lord Forrest and H Ranford on several overland expeditions in the 1880's. Dilyan was an aboriginal thought to have come from Wagin and spent his last years in the Boddington district.

- Mokine;
  A large homestead constructed from local stone (bauxite). This represents a rare example of the use of local stone in building in the early homesteads of the district.

- Red Hill;

A small red brick homestead with an iron roof located in the gully below Red Hill. Early in 1883, the building was used as a Post Office and is one of the few remaining early homesteads in the district.

- Homestead - mud brick;
  A small mud brick cottage with an iron roof. One of the few early homesteads of this type remaining in the district.

These places identified as having cultural heritage significance will be protected from bauxite mining and associated activities.

### 6.6.1 Aboriginal Heritage

*Objective*

To comply with statutory requirements for aboriginal heritage.

Worsley have conducted two detailed surveys throughout the project area to produce information about the occurrence and nature of Aboriginal sites (Pearce, 1981 and Pearce, 1984). In addition, interviews with people who were born in or near the area were held to establish the ethnography of the area.

Prior to the Worsley surveys, no systematic survey had been conducted, and no sites had been recorded in the project areas.

As a result of the Worsley surveys, a number of archaeological sites have been located throughout the project area. Of these sites, eight have been categorised as being potentially important to archaeological studies and have been registered with the WA Museum.

Ethnography reveals only vague or indirect data about a small number of places in or near the project area. The majority of sites in the area have therefore been assessed archaeological means and are typical of the occurrences of sites throughout the jarrah forest.

Artefacts found at the majority of locations indicate the sites were used for ordinary transient occupation. None of the sites found in the project areas are currently used for traditional purposes. In terms of any existing use or significance attributed under relevant Aboriginal custom, no places nor objects within the survey area can be considered important (Pearce, 1981).

***Aboriginal Heritage Commitments***

| |
|---|
| 100.Ensure project operations do not adversely affect sites identified as having potential archaeological significance. |

### 6.6.2 National Estate Listing

No area within the PBA is listed on the National Estate Register, but it is believed that Russell Forest Block in the northern part of mining lease ML 258SA has been recently nominated for listing. Worsley will be holding discussions with the Australian Heritage Commission on the values and its implications on future mining.

# 7. DECOMMISSIONING AND RETURN OF REHABILITATION AREAS

Project proposals submitted in the draft ERMP outlined a mining and refining operation which would continue for approximately 60 years, at a capacity of up two million tonnes per year. The proposed expansion will shorten the original project life within the PBA to approximately 30 - 35 years. Further bauxite may subsequently be mined from the southern and northern parts of ML 258SA (Section 4.1.2).

*Objectives*

To decommission the refinery and associated infrastructure in an environmentally acceptable manner that leaves no financial liability to the State and is in accordance with statutory requirements.

To progressively return areas of rehabilitation to the State (or where appropriate - private) management.

***Existing Environmental Conditions and Commitments***

Project approval in 1980 involved a commitment by the Worsley Joint Venturer to rehabilitate all areas affected by project activities.

The statutory basis of project rehabilitation requirements for the Worsley bauxite/alumina operation are specifically contained in the Agreement Act, the ERMP and subsequent project approvals.

Rehabilitation strategies previously described take into consideration other relevant legislation.

***Decommissioning Strategy***

The varied mining, transport and refining operations of the Worsley Project require the consideration of a number of issues in the preparation of a decommissioning strategy. This section outlines decommissioning issues, objectives, principles and a commitment to a process by which agreed closure and completion criteria may be developed for areas to be decommissioned or returned to the State.

Protection of bio-diversity and rehabilitation to agreed land uses for disturbed areas is a key aspect of Government acceptance of proposed rehabilitation strategies for both current and future mining and refinery areas.

Historically Worsley's mining operations have been conducted primarily in Timber Reserves. However, the rehabilitation of private land (primarily pasture) is emerging as a substantial consideration as bauxite mining operations expand to include private land (section 4.1.2).

Worsley is also committed to rehabilitating bauxite residue disposal areas (section 5.4.3). The major consideration for decommissioning these areas is the protection of local water resource values.

In meeting the rehabilitation commitments for these key areas, extensive environmental studies and research have been initiated, much of which supplements the initial comprehensive biological and technical baseline studies conducted in association with the original project development. The thrust of this research is to develop rehabilitation strategies to achieve cost effective, long term stability of land form, hydrology and revegetation of project areas, together with the maximisation of bio-diversity.

To address issues of decommissioning, the project has been broken up into key areas and objectives/principles assigned to each area (Table 24).

**Table 24: Decommissioning Objectives.**

| No. | Area | Decommissioning Objective/Principles |
|---|---|---|
| 1 | bauxite mine pits | To have a sustainable forest ecosystem with floral characteristics similar to the eastern Darling Range forest.<br><br>Specific goals to be achieved include the maintenance of recreation, conservation, landscape, water resource and forest values. |
| 2 | bauxite mine infrastructure | To remove infrastructure and rehabilitate exposed areas to ensure that agreed forest values are restored. |
| 3 | bauxite conveyor corridor | If necessary remove the conveyor system superstructure and rehabilitate the conveyor or corridor to the requirements of the State. All or sections of the roadway which are of value may be left intact by agreement with the State. |
| 4 | bauxite residue disposal areas | To ensure in the long term that contamination from residue disposal areas does not adversely affect the environmental values of offsite ground and surface waters. |
| 5 | Refinery pipehead dams | same as 4 above. |
| | Refinery water bodies (freshwater lake and refinery catchment lake) | same as 4 above. |
| 7 | Refinery solar evaporation ponds | same as 4 above. |
| 8 | Refinery process area | To remove infrastructure and rehabilitate exposed areas to a sustainable forest common to the area.<br><br>To clean up any soil or groundwater contamination to ensure the environmental values of offsite surface and groundwaters are not adversely affected in the long term. |

For each of the areas in Table 24 Worsley is developing options and strategies for decommissioning in order to formulate a comprehensive decommissioning plan. The

plan will be developed in consultation with the relevant government agencies and will be periodically reviewed to ensure that:

(i) rehabilitation strategies for key operations areas are kept current in respect of new environmental standards and regulations;

(ii) financial estimates for rehabilitation provisions are kept current for key project areas; and

(iii) emerging issues relevant to project rehabilitation are identified well in advance of decommissioning.

Given that a number of Government agencies will have input to the decommissioning and rehabilitation plans, Worsley supports the view that these plans to be developed and reviewed through the existing Environmental Management Liaison Group (EMLG). This Group currently reviews the annual and triennial environmental management reports submitted pursuant to the Agreement.

***Rehabilitation Completion Criteria***

Completion criteria are defined as a series of standards that once developed can be used to determine when an area is sufficiently rehabilitated to be incorporated with adjacent forested land and managed for its agreed land use values. This includes a divesting of management responsibility from Worsley to CALM. The principles involved in assigning completion criteria to rehabilitation are based on and include the following environmental values:

- landscape consistency with pre-mining landform;
- flora species richness;
- re-establishment of forest access road network;
- fauna recolonisation;
- tree establishment;
- landform stability;
- water drainage and erosion control; and
- forest disease.

***Decommissioning and Return Rehabilitated Land Commitments***

101. Prepare decommissioning plans in accordance with land use objectives.

102. Develop closure plans in consultation with key agencies.

103. Undertake regular review of decommissioning plans to take into account emerging issues and the findings of research.

104. Develop completion criteria for rehabilitation in consultation with CALM and other key agencies.

# 8. CONCLUSIONS

The proposed expansion of the Worsley Alumina Refinery to a production capacity of 3.5 Mt/a will result in incremental increases in the rates of bauxite mining and conveying, energy consumption and emissions relating to refining operations, together with the transport of raw materials and shipping of alumina.

These incremental increases represent an acceleration of the rate of production and implementation of the initial Worsley Alumina Project, approved in 1979.

The expansion will result in an increased mining rate within areas previously approved for mining under the *Alumina Refinery (Worsley) Agreement Act 1973*. Mining will progress through the Primary Bauxite Area over a period of 30-35 years and beyond this time into other areas within Worsley's mining lease.

The proposed expansion will increase the efficiency of the existing refinery and associated facilities and involve the installation of new process facilities and the refitting of some existing equipment.

The liquor purification facility represents the only addition to the existing Bayer technology employed at the refinery.

The specific rate of consumption of energy will decrease by 10%, resulting in lower rates (11-15%) of emissions per tonne of alumina produced.

Increased water consumption within the refinery will be satisfied in the medium and longer term by increasing the yield from the refinery catchment and by the current recovery of recycled water.

There will be no need to increase the area originally approved for residue deposition in order to accommodate the expansion for present proven bauxite reserves within the Primary Bauxite Area.

The proposed expansion would be undertaken within the existing approved framework of environmental management programs that were established with the initial project and have been refined in conjunction with subsequent project developments.

To facilitate review of statutory reporting and auditing of Worsley's environmental management programs, and to address life-of-project considerations, Worsley support the further development and formalisation of the existing, government environmental management liaison group.

Worsley's philosophy of excellence in environmental management, underlies the company's commitment to the ongoing use of best practicable means and continuous improvement, through research and development, in the implementation of its environmental management programs.

# 9. LIST OF ENVIRONMENTAL COMMITMENTS AND SUMMARY OF WORSLEY ALUMINA'S ADVICE TO THE ENVIRONMENTAL PROTECTION AUTHORITY

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Performance Audit/Reveiw | Environmental Management Approach | 5.1 | • To achieve excellence in environmental management. | 1. Formalise Worsley's interaction with the Government expert panel (Environmental Management Liaison Group). | 3. | DRD |
| | | | | 2. Prepare environmental audit plans for the bauxite mine and refinery. | 4a. | EMLG |
| | | | | 3. Undertake regular internal audits of key processes. | 4b. | EMLG |
| | | | | 4. Prepare and submit annual environmental management reports to the State. | 4a. | EMLG |

## MINING OPERATIONS

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Biophysical Environment | Conservation of Flora and Fauna | 5.2.1 | • To ensure that the biodiversity and sustainability of the eastern Darling Range forest ecosystems are maintained from adverse impacts of bauxite mining activities.<br>• To ensure that rare and endangered flora and fauna within the mining area are protected. | 5. Undertake baseline flora and fauna surveys prior to mining in new areas. | 4a. | CALM (EMLG) |
| | | | | 6. Regularly monitor the abundance and distribution of flora and fauna in forest adjacent to mined areas. | 4a | EMLG |
| | | | | 7. Defer mining in areas of potentially high conservation values in the Primary Bauxite Area (PBA) until it can be shown that the biodiversity and sustainability of the ecosystem will not be adversely affected. | 4a. | EMLG |
| | | | | 8. Encourage recruitment of rare or priority flora and rare and endangered fauna into rehabilitated areas. | 4a | EMLG |
| | | | | 9. Investigate the creation of a wildlife corridor linking the Saddleback and George forest blocks. | 4c | EMLG |
| | | | | 10. Implement a feral animal and weed control program. | 4b | CALM (Agric) |
| | | | | 11. Support recalcitrant plant species research applicable to Worsley Alumina's bauxite mining operations. | 4a | EMLG |

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Biophysical Environment | Rehabilitation Management | 5.2.2 | • To ensure that rehabilitation of mined areas in State Forest is timely, sustainable and meets completion criteria agreed by the State.<br>• To ensure that rehabilitation of mined areas on private property leaves the land in an environmentally stable and sustainable condition and meets the requirements of the private property owner. | 12. Trial re-creation of fauna habitats in rehabilitation.<br>13. Monitor flora establishment and development by measurement of species richness, abundance and tree growth rates.<br>14. Work with CALM to further develop rehabilitation enhancement techniques (including direct seeding).<br>15. Revegetate State forest areas with seed collected from local provenance areas.<br>16. Minimise the time between clearing for mining and rehabilitation of areas that have high visual aesthetic values.<br>17. Use vegetation screening in areas of significant visual impact where practicable. | 4a<br>4a<br>4a<br>4a<br>4a<br>4a | CALM (EMLG)<br>CALM (EMLG)<br>CALM<br>CALM (EMLG)<br>CALM (EMLG)<br>EMLG |
| Biophysical Environment | Forest Disease Management | 5.2.3 | • To minimise the risk of bauxite mining activities introducing or spreading jarrah dieback or other forest diseases into areas of State and private forest. | 18. Maintain a dieback disease management strategy and hygiene procedures.<br>19. Support research relevant to forest disease management and Worsley's operations.<br>20. Rehabilitate forest project areas affected by jarrah dieback.<br>21. Monitor the rate and spread of forest disease infections in the mining area. | 4a<br>4a<br>4a<br>4a | CALM (EMLG)<br>CALM (EMLG)<br>CALM (EMLG)<br>CALM (EMLG) |
| Biophysical Environment | Integration with CALM Forest Management | 5.2.4 | • To minimise the impacts of bauxite mining activities on other users of the State Forest, by integrating as far as practicable Worsley's activities with CALM's forest management. | 22. Work with the State to identify areas of ML 258SA outside the PBA with potentially high conservation value that can be precluded from mining without significant impact on the life of the project.<br>23. Work with CALM to implement the integrated fire management plan with particular emphasis on protection of rehabilitation.<br>24. Work with CALM to maximise the salvage of forest products prior to clearing.<br>25. Co-operate with the Agriculture Department, CALM and the local community to develop a fox control strategy in the Primary Bauxite Area (PBA). | 4a<br>4a<br>4a<br>4a | EMLG<br>CALM<br>CALM<br>CALM (Ag Dept) |

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Pollution Potential | Water Resource Management and Protection | 5.2.5 | • To ensure that environmental values of water resources are maintained from adverse impacts of bauxite mining activities. | 26. Investigate alternative sources of water supply. | 1 | WAWA (EMLG) |
| | | | | 27. Investigate means of increasing the effective use of water for dust suppression. | 4a | DOME (EMLG) |
| | | | | 28. Monitor regularly the conductivity in surface waters in areas adjacent to mining activities, groundwater levels in harnessed borefields and the health of the Tunnell Road heathland. | 4a | EMLG |
| | | | | 29. Investigate stored salt in the soil profile in the Marradong and Hotham North areas prior to mining. | 4a | EMLG |
| | | | | 30. Defer mining within the Hunt A Catchment until after 1998. | 4a | EMLG |
| Pollution Potential | Noise and Blast Vibration Management | 5.2.6 | • To comply with statutory requirements so that the amenity of nearby residents is protected from noise impacts resulting from bauxite mining activities. | 31. Amend mining operations as necessary to comply with noise regulations. | 4a | EMLG |
| | | | | 32. Predict sound levels for mining operations and routinely verify the output of the ENM model. | 4a | DEP (EMLG) |
| | | | | 33. Continue with the outlined program of sound power reduction initiatives for mining equipment and fixed plant. | 4a | DEP (EMLG) |
| | | | | 34. Plan mine development to facilitate the management of sound levels from mining operations. | 4b | EMLG |
| | | | | 35. Specify low sound power levels and minimum unfavourable sound characteristics as far as practicable when selecting new mining equipment and plant. | 4b,1 | DOME (EMLG |
| | | | | 36. Monitor the air blast over pressure level of each blast at the most sensitive premises and report the findings to the DEP annually. | 4a | DEP (EMLG) |
| | | | | 37. Investigate and identify corrective action when any blast creates air blast overpressure greater than 110 dB(lin) peak at a monitoring location. | 4a | DEP (EMLG) |
| | | | | 38. Report to the DEP any blast that creates airblast overpressure greater than 120 dB(lin) peak. | 4a | DEP (EMLG) |
| | | | | 39. Measure ground vibration levels when new areas are opened for mining. | 4b | DEP (EMLG) |
| | | | | 40. Investigate complaints and take corrective action where required. | 4a | DEP (EMLG) |

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Pollution Potential | Dust Management | 5.2.7 | • To comply with statutory requirements so that the amenity of nearby residents is protected from dust impacts resulting from bauxite mining activities. | 41. Use water on haulroads and fixed plant to suppress dust.<br>42. Trial additives to increase the efficiency water as a dust suppressant. | 4a<br>4a | DOME<br>DOME |
| Pollution Potential | Waste Management | 5.2.9 | • To reduce as far as practicable the generation of solid and liquid wastes resulting from bauxite mining activities.<br>• To dispose of waste in an environmentally acceptable manner. | 47. Investigate where practicable alternatives for on-site re-use / re-cycling of waste oil.<br>48. Assist the Shire of Boddington to locate an additional landfill site to meet the future waste disposal needs of the local community and Worsley. | 4a<br>4a | DEP<br>EMLG |
| Social Surrounding | Control of Public Access and Safety | 5.2.8 | • To restrict access by the general public to the mine operating areas in accordance with safety requirements. | 43. Maintain perimeter security fencing and signposting and gate, or otherwise block-off forest tracks by arrangement with CALM.<br>44. Clear blasting areas and post sentries prior to and during blasting.<br>45. Seek State approval of mine and public road intersections and management arrangements.<br>46. Re-establish the forest road network after mining, in consultation with CALM. | 4a<br>4a<br>4a<br>4c | CALM (EMLG)<br>DOME<br>EMLG<br>CALM |

## OVERLAND BAUXITE CONVEYOR

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Biophysical Environment | Forest Management | 5.3.1 | • To ensure operation of the overland conveyor has minimal impact on forest ecology.<br>• To minimise the risk of spreading jarrah dieback in forest areas adjacent to conveyor operations. | 49. Continue implementation of the Overland Conveyor Forest Disease Hygiene Prescription to minimise the risk of spread of jarrah dieback.<br>50. Conduct periodic review of the Overland Conveyor Forest Disease Hygiene prescription in consultation with CALM.<br>51. Conduct regular inspection and monitoring of forest health within and adjacent to the overland conveyor corridor in conjunction with CALM.<br>52. Continue the annual CALM Interagency Agreement for Wildfire suppression. | 4a<br>4a<br>4a<br>4a | CALM<br>CALM<br>CALM<br>CALM |

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| | | | | 53. Conduct periodic monitoring to measure the success of fauna habitat protection. | 4a | EMLG |
| Pollution Potential | Noise Management | 5.3.2 | • To ensure noise emissions from the conveyor comply with statutory requirements. | 54. Investigate where practicable mitigation measures to reduce noise emissions from the conveyor in the proximity to noise sensitive areas.<br>55. Monitor noise emissions from the overland conveyor to ensure compliance with the prescribed limit of 60 dB (A) as prescribed under the 1995 amendments to the Agreement Act limit. | 4a<br>4a | DRD<br>DRD |

## REFINERY OPERATIONS

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Pollution Potential | Atmospheric Emissions | 5.4.1 | • To comply with statutory requirements so that the ecological values of off-site areas and the amenity and health of nearby residents are protected from adverse atmospheric emissions from the refinery operations. | 56. Monitor gases and particulate emissions from the powerhouse and calciner stacks.<br>57. Incorporate best practicable pollution suppression equipment on new plant which discharges to the atmosphere.<br>58. Monitor ground level concentrations of $SO_2$ and $NO_x$ at nearby residences to validate dispersion modelling.<br>59. Monitor meteorological conditions suitable for prediction of plume rise and dispersion.<br>60. Quantify emissions of volatile organic compounds from the liquor purification facility. | 4a<br>1,4a<br>4b<br>4a<br>4b | DEP<br>DEP<br>DEP<br>DEP<br>DEP |
| Pollution Potential | Water Resource Management and Protection | 5.4.2 | • To ensure that environmental values of ground water resources are maintained from adverse impacts of refinery operations and bauxite residue disposal. | 61. Monitor the quality of groundwater in the refinery lease area, within and downstream from the freshwater lake.<br>62. Conduct periodic ecological monitoring of the ecosystem immediately downstream of the freshwater lake.<br>63. Recover or treat any contaminated groundwater.<br>64. Maintain a basal summer flow of approximately 35 $m^3$/hr from the freshwater lake.<br>65. Report monitoring results annually to the Government in accordance with provisions of the Agreement Act. | 4a<br>4a<br>4a<br>4a<br>4a | WAWA<br>EMLG<br>DEP<br>WAWA<br>DRD |

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| | | | | 66. Continue to implement the refinery lease water management system designed to separate, contain, and where practicable, reuse contaminated wastes. | 4a | WAWA (DEP) |
| | | | | 67. Implement spills management in consultation with relevant government agencies. | 4a | EMLG |
| | | | | 68. Monitor comprehensively the condition of plant and equipment. | 4a | EMLG |
| | | | | 69. Evaluate and periodically update Worsley's emergency response plan for hazardous materials. | 4a | DOME |
| Pollution Potential | Management of Bauxite Residue | 5.4.3 | • To design, construct and operate the residue areas in a manner that maintains the integrity of the containment system.<br>• To maximise as far as practicable the extraction of caustic soda from the bauxite residue.<br>• To minimise, as far as practicable, impacts on State Forest resulting from construction activities.<br>• To manage the residue areas in an environmentally acceptable manner until they meet the requirements of a closure and rehabilitation strategy agreed with the State. | 70. Monitor ambient dust throughout the refinery lease area and adjacent to the bauxite residue disposal areas. | 4a | DEP |
| | | | | 71. Minimise fugitive dust from the bauxite residue disposal areas. | 4a | DEP |
| | | | | 72. Develop a rehabilitation prescription for the bauxite residue disposal areas. | 4c | EMLG |
| | | | | 73. Develop a long term management plan for the bauxite residue disposal areas which includes a closure strategy, in conjunction with relevant Government agencies. | 4c | EMLG |
| | | | | 74. Continue to implement a system of quality control for construction of bauxite residue disposal areas. | 4a | WAWA |
| | | | | 75. Continue to monitor underdrainage from the bauxite residue disposal areas. | 4a | WAWA |
| | | | | 76. Monitor alternative uses of bauxite residue. | 4c | EMLG |
| Pollution Potential | Hazard Management | 5.4.4 | • To minimise the risk of spillage of materials which cause harm to either the environment or personnel. | 77. Implement a comprehensive program of safety awareness and training for identification and prevention of hazards. | 4a | DOME |
| | | | | 78. Periodic review of the emergency response plan for hazardous material in accordance with the Explosives and Dangerous Goods Act. | 4a | DOME |
| Pollution Potential | Waste Management (Other than bauxite residue) | 5.4.5 | • To reduce as much as practicable the generation of solid and liquid waste resulting from refinery operations.<br>• To dispose of wastes in an environmentally acceptable manner. | 79. Continue the philosophy of waste minimisation. | 4a | EMLG |
| | | | | 80. Promote the reuse or recycling of wastes where practicable. | 4 | DEP |
| | | | | 81. Operate the refinery sanitary landfill site in a manner that protects the values of surface and groundwaters. | 4a | Dept of Health |

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Pollution Potential | Noise Management | 5.4.6 | • To comply with statutory requirements so that the amenity of nearby residents is protected from noise impacts resulting from refinery operations. | 82. Conduct periodic acoustic assessment at nearest sensitive premises to the refinery to ensure continued compliance with statutory requirements. | 4a | DEP |
| Pollution Potential | Greenhouse Gas Management | 5.5 | • To reduce as much as practicable the net emission of greenhouse gases from project operations. | 83. Preserve greenhouse sinks on Joint Venturer-owned land.<br>84. Minimise burning of forest debris.<br>85. Remove all project halon-fixed flooding fire extinguishing systems.<br>86. Reafforest an area of Joint Venturer-owned land equivalent to any sustained increase in the open area of the mine.<br>87. Investigate the potential to improve energy efficiency of calciners, power generation and steam raising facilities.<br>88. Investigate where practicable alternative fuel sources for lower greenhouse emissions. | 4b<br>4a<br>4b<br>4c<br>4b<br>4b | EMLG<br>CALM<br>DOME (DEP)<br>EMLG<br>EMLG<br>EMLG |

## SOCIAL ENVIRONMENT AND MANAGEMENT

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Social Surroundings | Community Support | 6 | • To reasonably assist local communities to manage social impacts arising from the construction and operational stages of Worsley's expansion. | 89. If required construct new Joint Venture-owned accommodation in the town of Boddington. | 4b | EMLG |
| | | | | 90. Take into account as far as practicable the concerns of local residents when considering shift arrangements for expanded mining activities. | 4b | EMLG |
| | | 6.1 | • Ensure that the local community is adequately consulted in relation to the expansion and any subsequent changes to the proposal. | 91. Participate in any appropriate Government co-ordinated consultative forum to address issues of workforce accommodation. | 2 | EMLG |
| | | 6.2.4, 6.3.4 & 6.3.5 | • To reduce as much as practicable the impacts of road and rail resulting from the project on the affected communities. | 92. Provide construction camp accommodation near the refinery if alternate accommodation is unavailable in the region. | 2 | EMLG |
| | | | | 93. Liaise with the Shire of Harvey prior to and during the construction phase of the project on the impact of construction traffic on Mornington Road. | 1,2 | EMLG |
| | | | | 94. Require contractors to access the Worsley Refinery via the Coalfield and Gastaldo Roads with vehicular traffic of 12 tonnes or more. | 2 | EMLG |

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| | | | | 95. Participate in any Government co-ordinated working party to investigate and address issues of road safety and the upgrading of Mornington Road arising from the existing use and major regional construction projects. | 2,4a | EMLG |
| | | | | 96. If required, stagger start and finish times of construction and operations workforce shifts at the refinery. | 2 | EMLG |
| | | | | 97. Subject to periodic review, continue existing programs to support community groups, infrastructure and services. | 4a | EMLG |
| Social Surroundings | Maintenance of Separation Distance | 6.5 | • To maintain appropriate separation distances between project operations and sensitive areas in conjunction with relevant planning authorities. | 98. Retain Joint Venturer ownership of land within buffer areas. | 4a | EMLG |
| | | | | 99. Pursue if required retention or establishment of buffer areas surrounding project locations through local town planning schemes and in consultation with the State. | 4a | EMLG |
| Social Surroundings | Aboriginal Heritage | 6.6 | • To comply with statutory requirements for the protection of aboriginal heritage. | 100. Ensure project operations do not adversely affect sites identified as having potential archaeological significance. | 4a | EMLG |

## DECOMMISSIONING AND RETURN OF REHABILITATED AREAS

| Category | Topic | Present State/ Potential Impacts (Refer to sections) | Objectives | Proposed Management Commitments | Phase* (Timing) | Key Agency** |
|---|---|---|---|---|---|---|
| Biophysical Environment | Decommis-sioning and Return of Rehabilitated Land | 7 | • To decommission the refinery and associated infrastructure in an environmentally acceptable manner that leaves no financial liability to the State and is in accordance with statutory requirements. | 101. Prepare decommissioning plans in accordance with land use objectives. | 4c | EMLG |
| | | | | 102. Develop closure plans in consultation with key agencies. | 4c | EMLG |
| | | | | 103. Undertake regular review of decommissioning plans to take into account emerging issues and the findings of research. | 4c | EMLG |
| | | | • To progressively return areas of rehabilitation to the State (or where appropriate - private) management | 104. Develop completion criteria for rehabilitation in consultation with CALM and other key agencies. | 4c | EMLG |

* Phase (Timing) Code:

1. Preconstruction (Expansion)
2. Construction (Expansion)
3. Commissioning (Expansion)
4. Operational (a) ongoing operations
   (b) commencing with expansion
   (c) before relinquishment to the State
5. Post operational

** Environmental Management Liaison Group (EMLG) comprises expert representatives of:

Department of Environmental Protection (DEP);
Department of Conservation and Land Management (CALM);
Water Authority of Western Australia (WAWA);
Department of Minerals & Energy (DOME); and
Department of Resource Development (DRD)

The group may also include, by invitation, representatives of Department of Agriculture, Department of Health (Environment), Local Government, Main Road Department and other representatives as may be required.

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# 11. ABBREVIATIONS

| | |
|---|---|
| AEC | Australian Environment Council |
| AHD | Australian Height Datum |
| ANZECC | Australian and New Zealand Environment Conservation Council |
| CALM | Department of Conservation and Land Management |
| CER | Consultative Environmental Review |
| cm | centimetres |
| dB | decibels (noise) |
| dB(A) | noise measurement weighted for the ears hearing characteristics |
| DEP | Department of Environmental Protection |
| DCE | Department of Conservation and Environment |
| DPUP | Department of Planning and Urban Development |
| EMLG | Environmental Management Liaison Group |
| ENM | Environmental Noise Model |
| EPA | Environmental protection Authority |
| EPP | Environmental Protection Policy |
| ERMP | Environmental Review and Management Program |
| g | gram |
| ha | hectare |
| hr | hour |
| kg | kilogram |
| km | kilometre |
| kV | kilovolt |
| L | litre |
| L1 | The noise level which is exceeded for 1% of time |
| L10 | The noise level which is exceeded for 10% of time |
| m | metre |
| mg | milligram |
| mm | millimetre |
| ML | Million litre (Megalitre) |
| MRWA | Main Roads Department of Western Australia |
| Mt/a | Million tonne per annum |
| NHMRC | National Health and Medical Research Council |
| PBA | Primary Bauxite Area |
| pH | measure of concentration of hydrogen ions (acidity or alkalinity) |
| t | tonne |
| µg | microgram |
| WAWA | Water Authority of Western Australia |

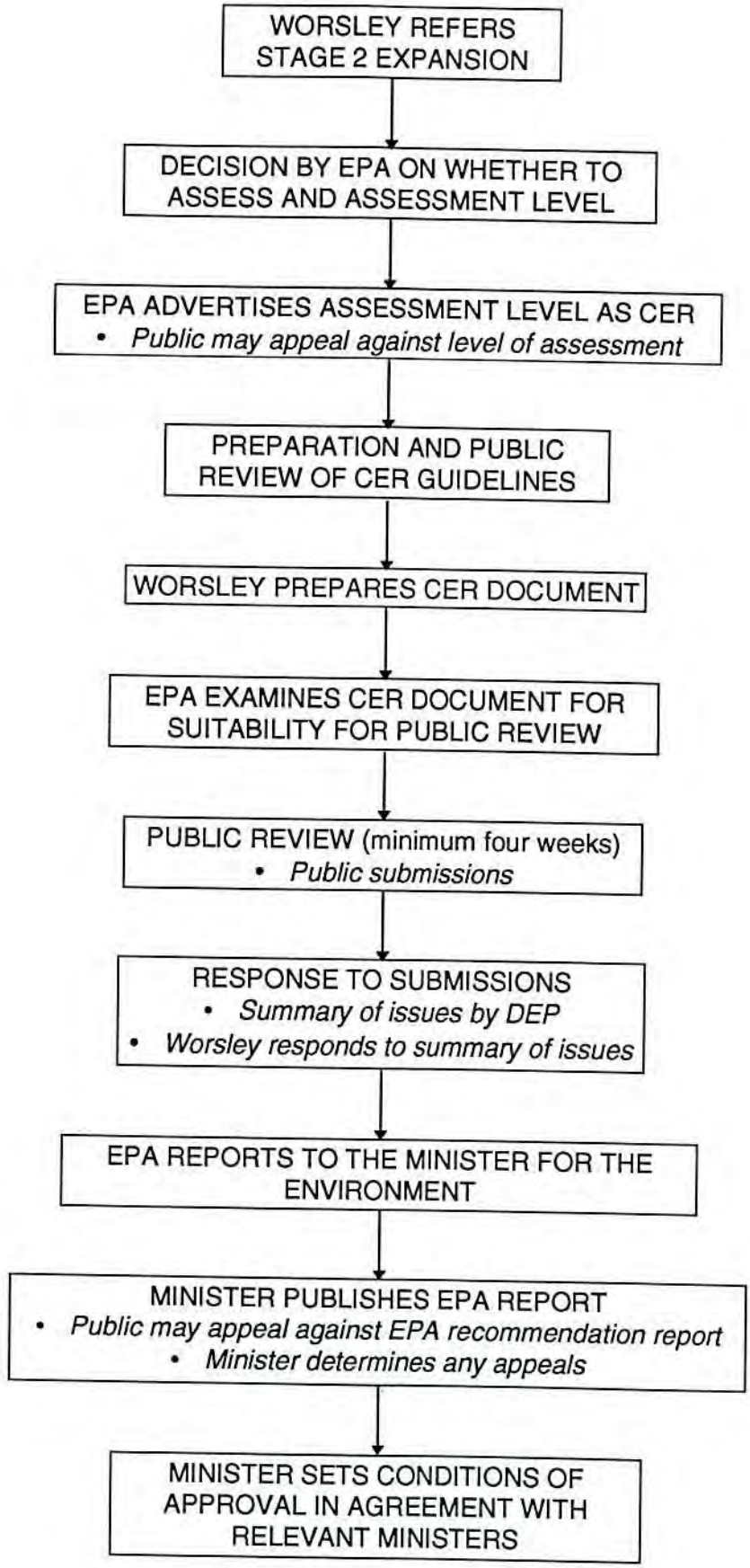
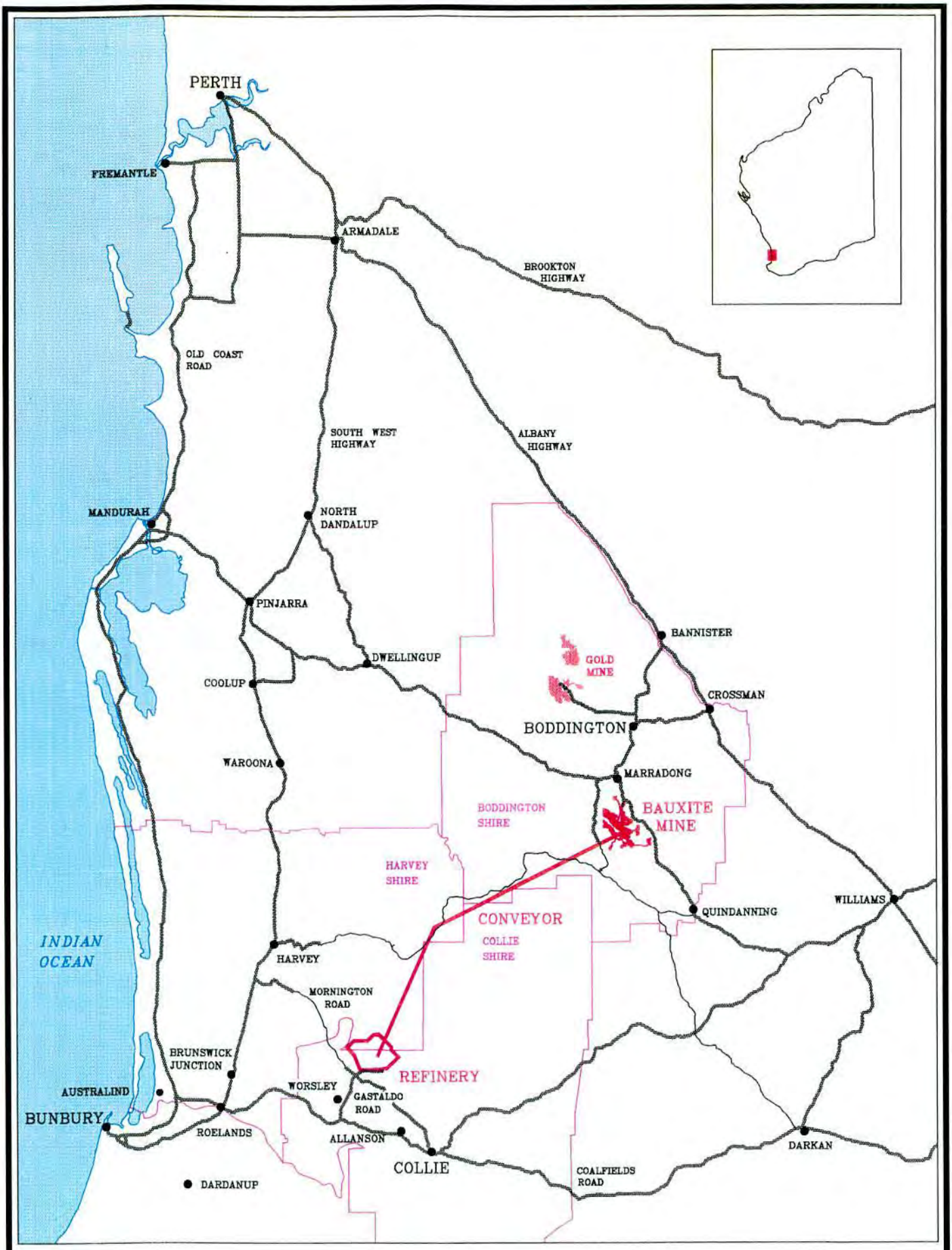
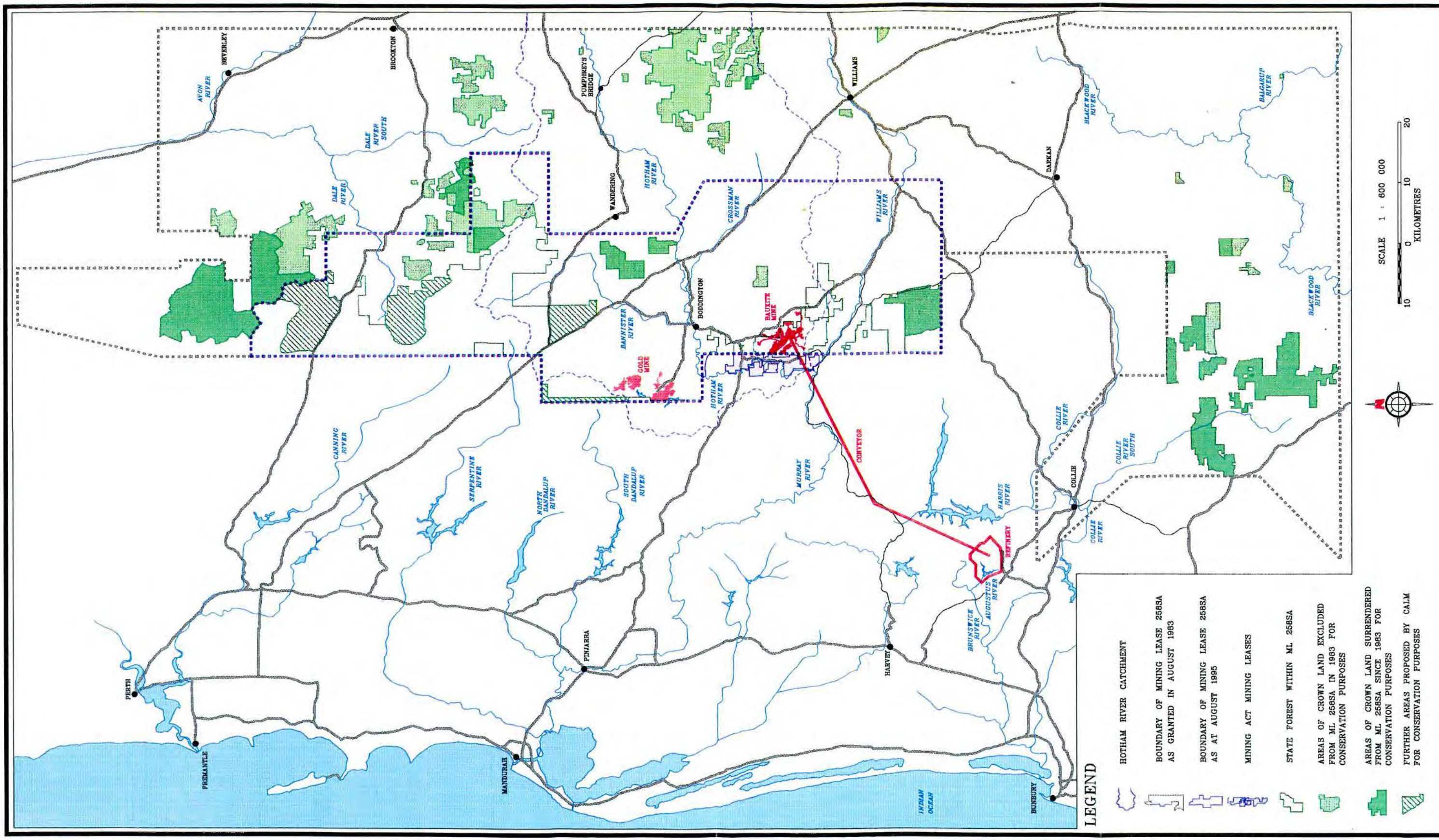



**Figure 1: Environmental Impact Assessment Process**



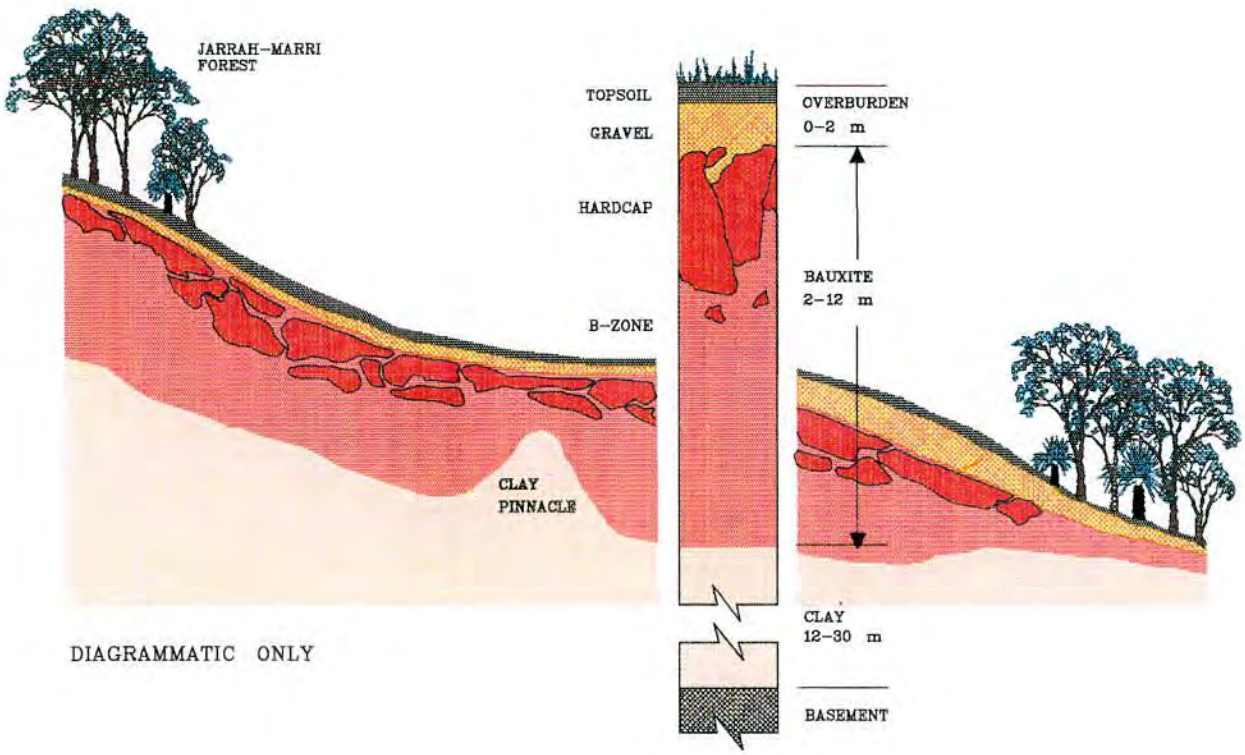

# PROJECT LOCATIONS

FIGURE 2




PROJECT MINING LEASES

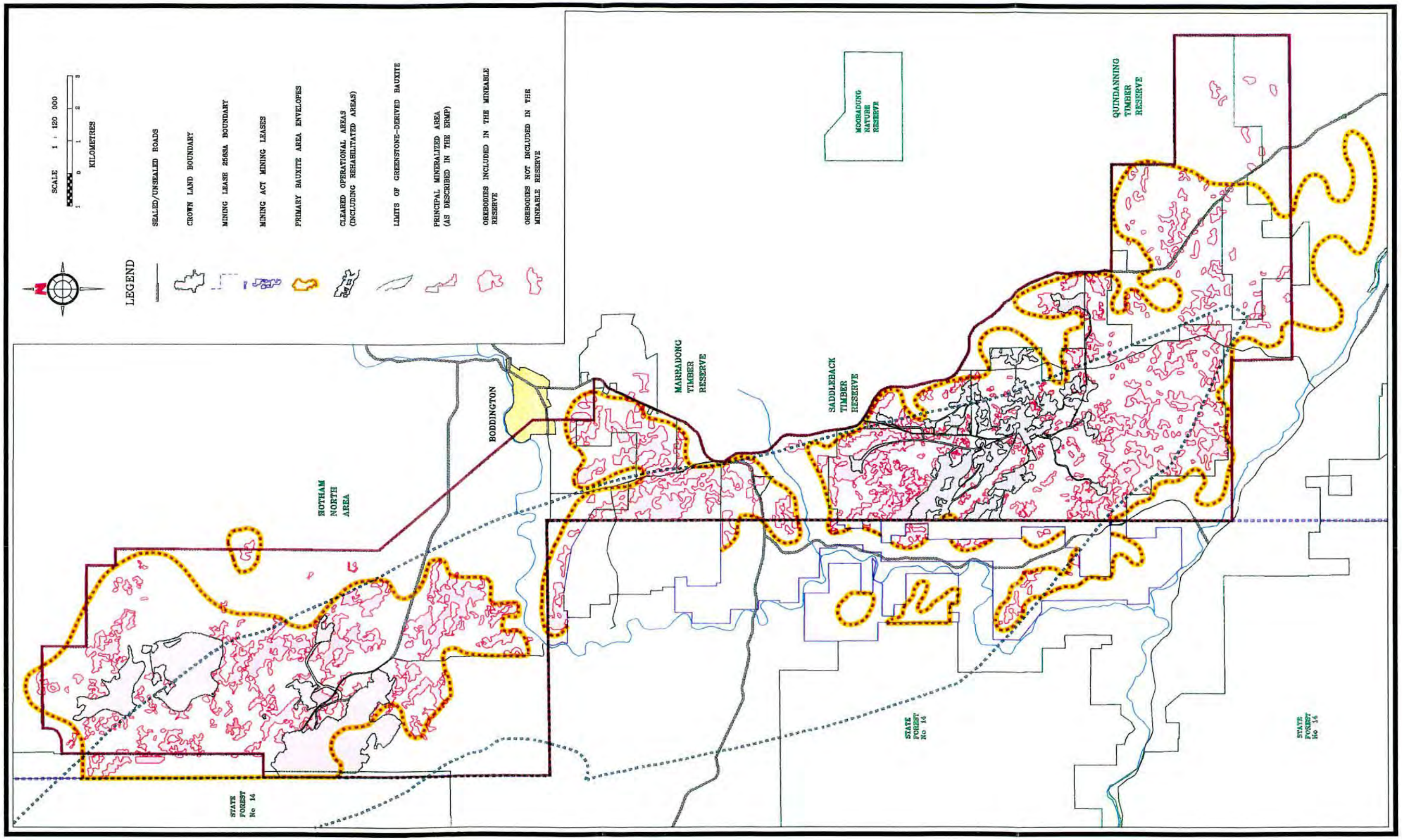
FIGURE 3




DIAGRAMMATIC ONLY

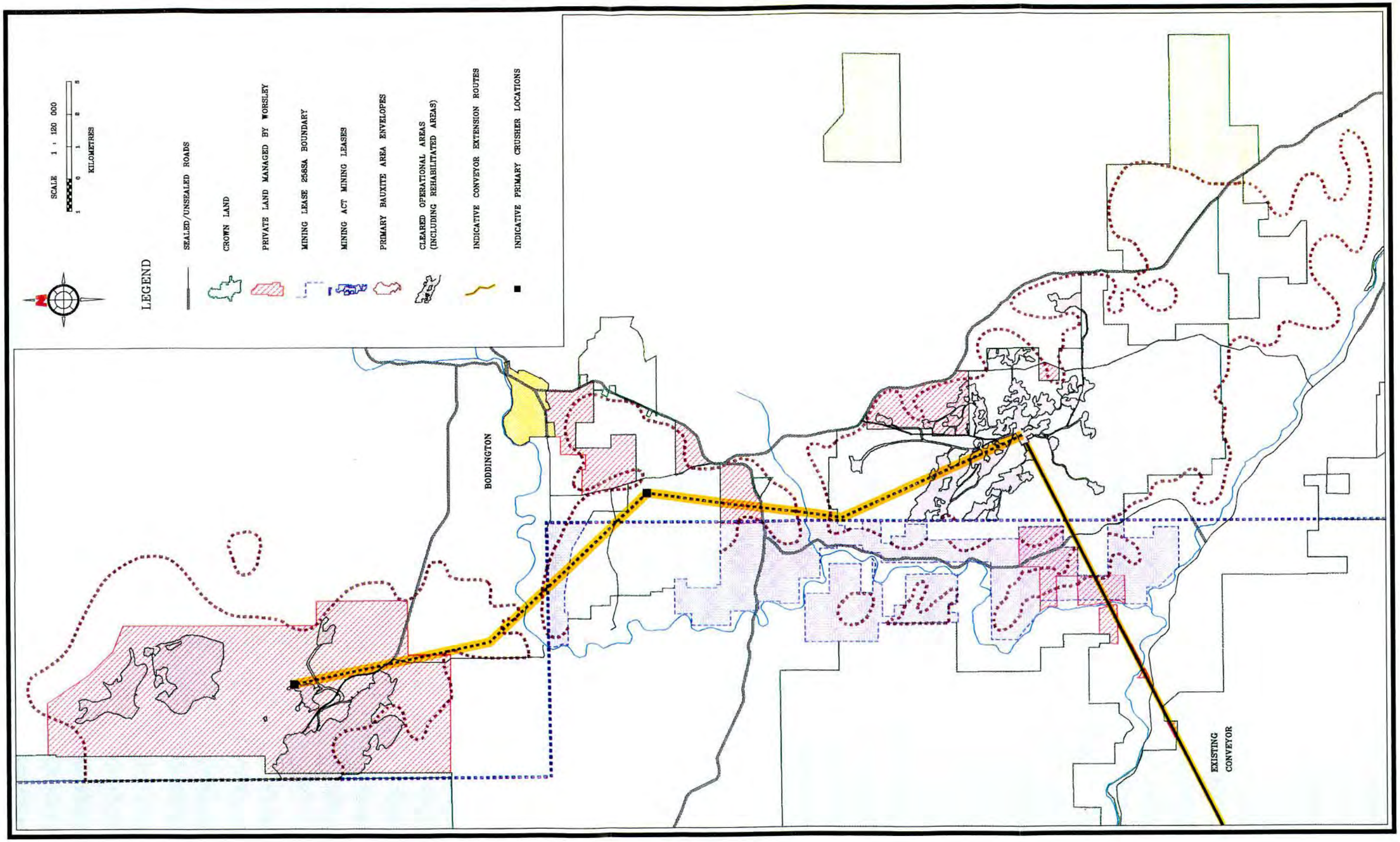
TYPICAL LATERITE–BAUXITE PROFILE

FIGURE 4



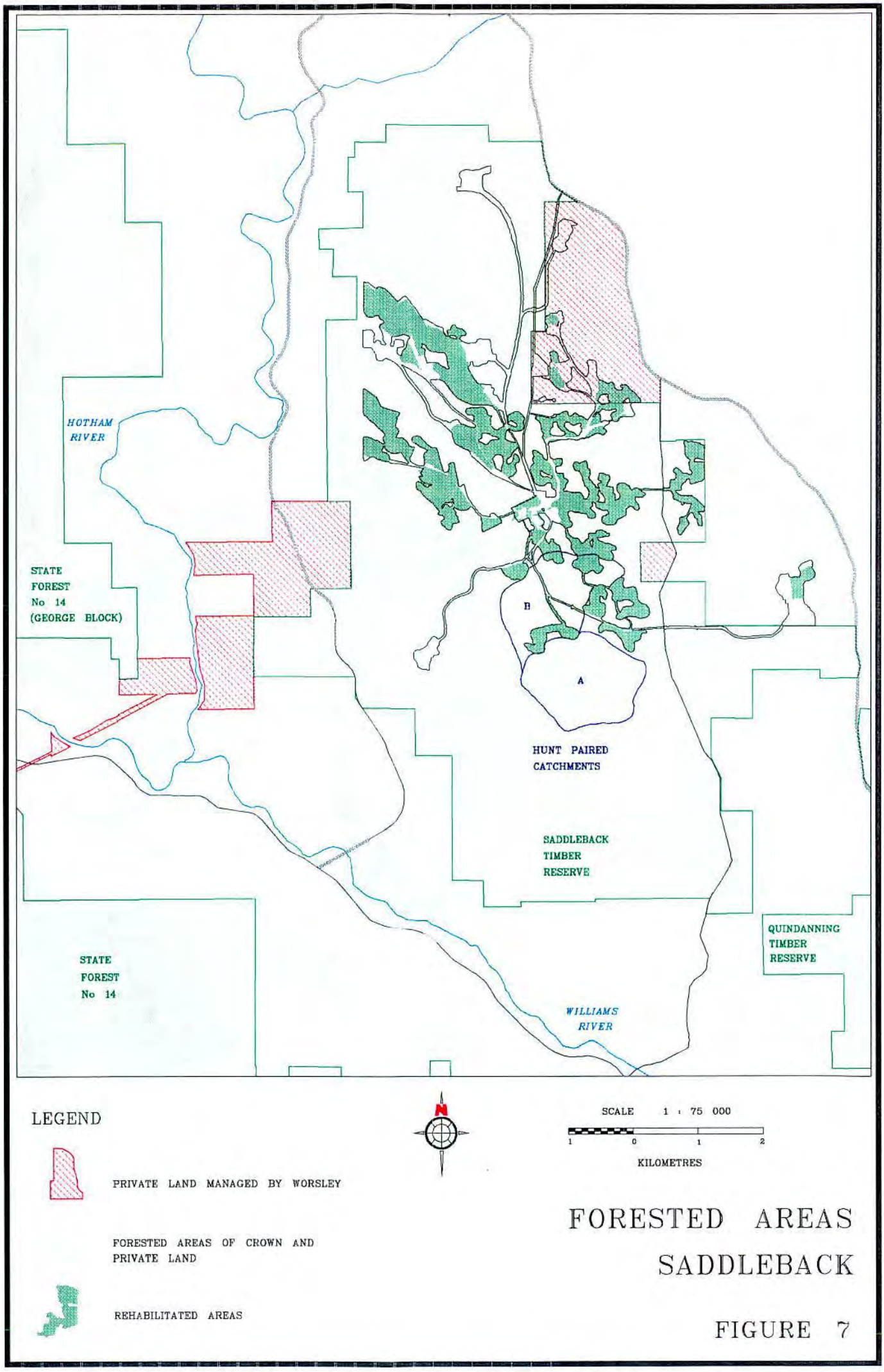

PRIMARY BAUXITE AREA

FIGURE 5



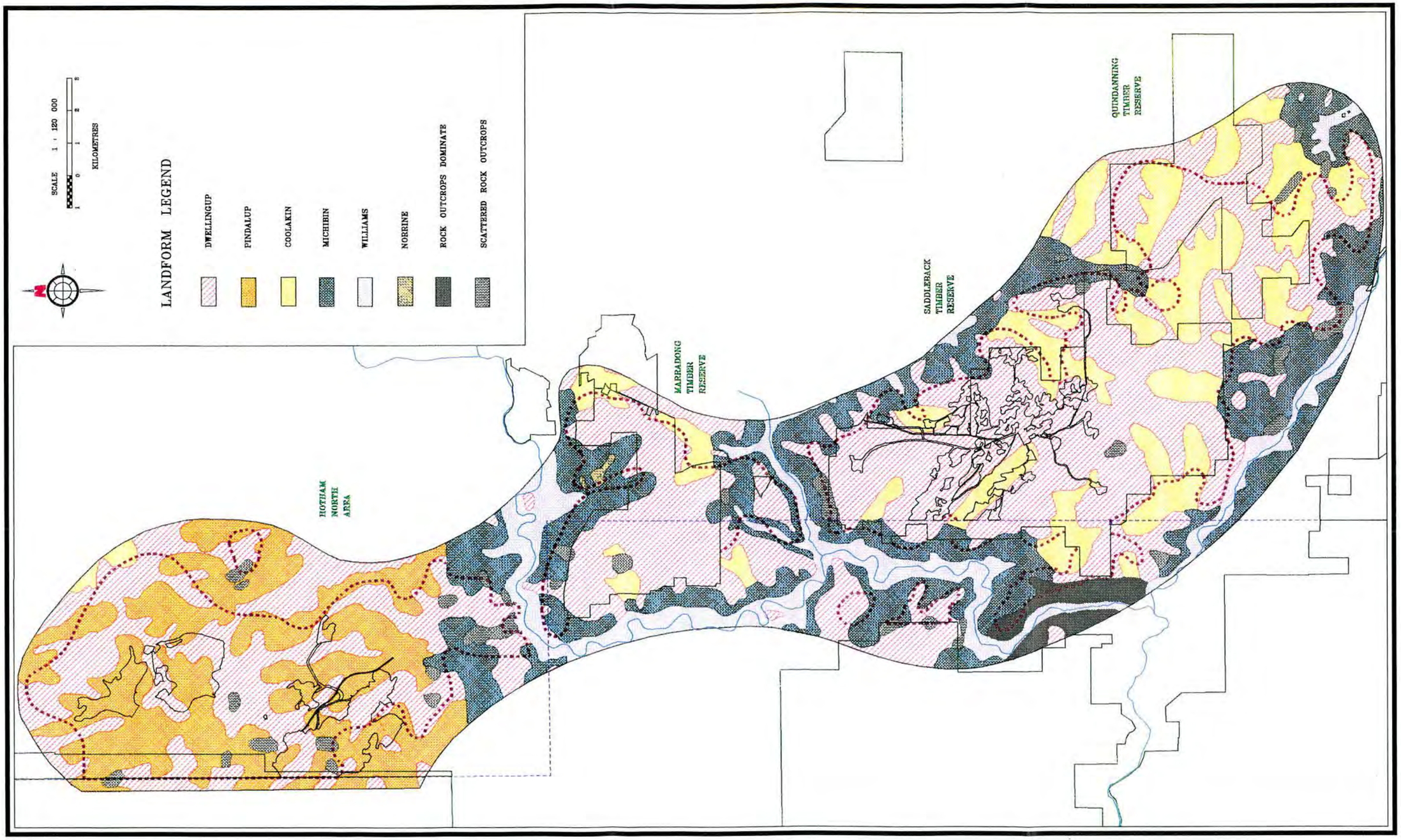

INDICATIVE CONVEYOR EXTENSION ROUTES

FIGURE 6



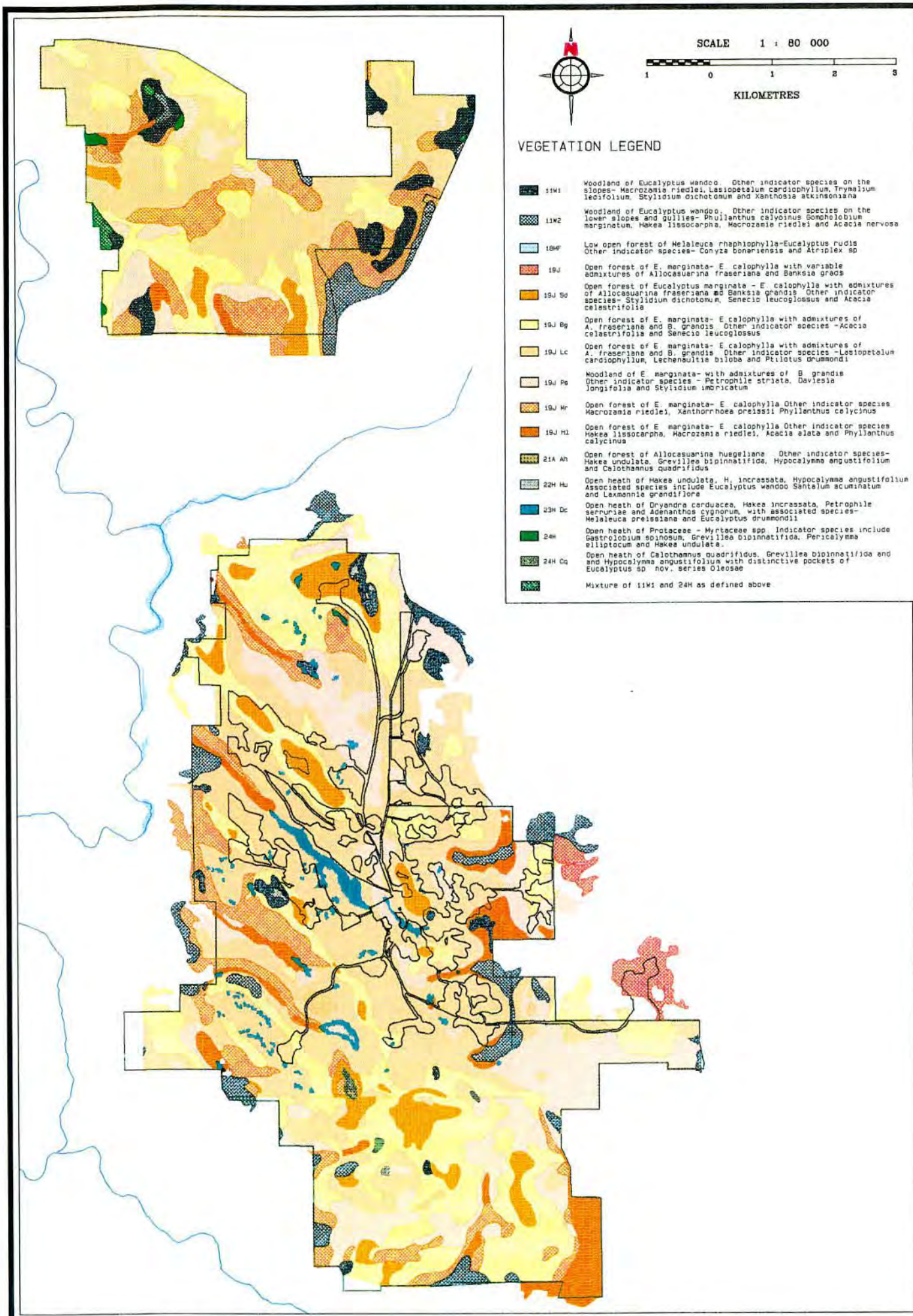

# FORESTED AREAS
# SADDLEBACK

FIGURE 7




LANDFORMS IN THE PBA

FIGURE 8




# SADDLEBACK AND MARRADONG AREA VEGETATION

FIGURE 9

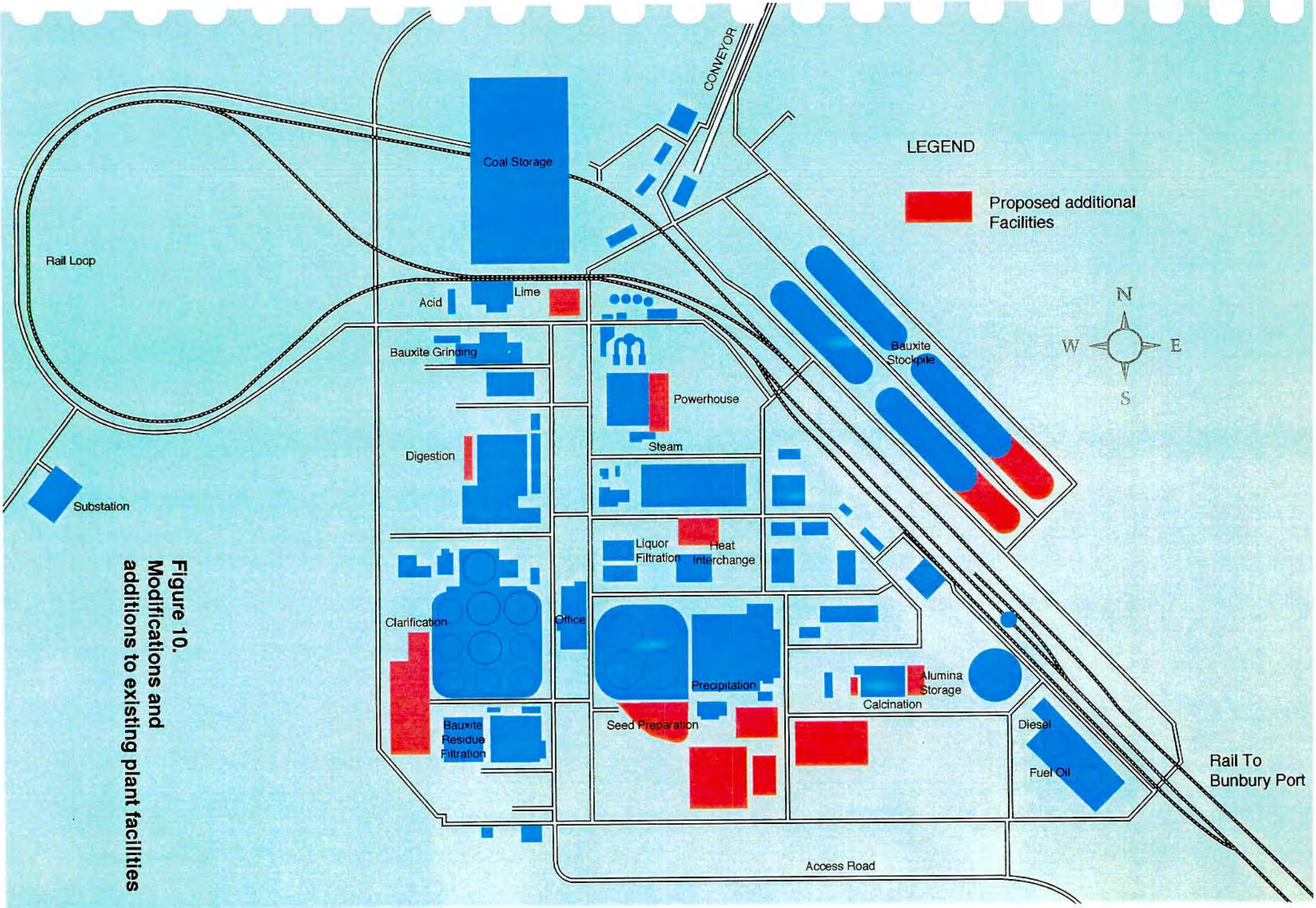



**Figure 10. Modifications and additions to existing plant facilities**

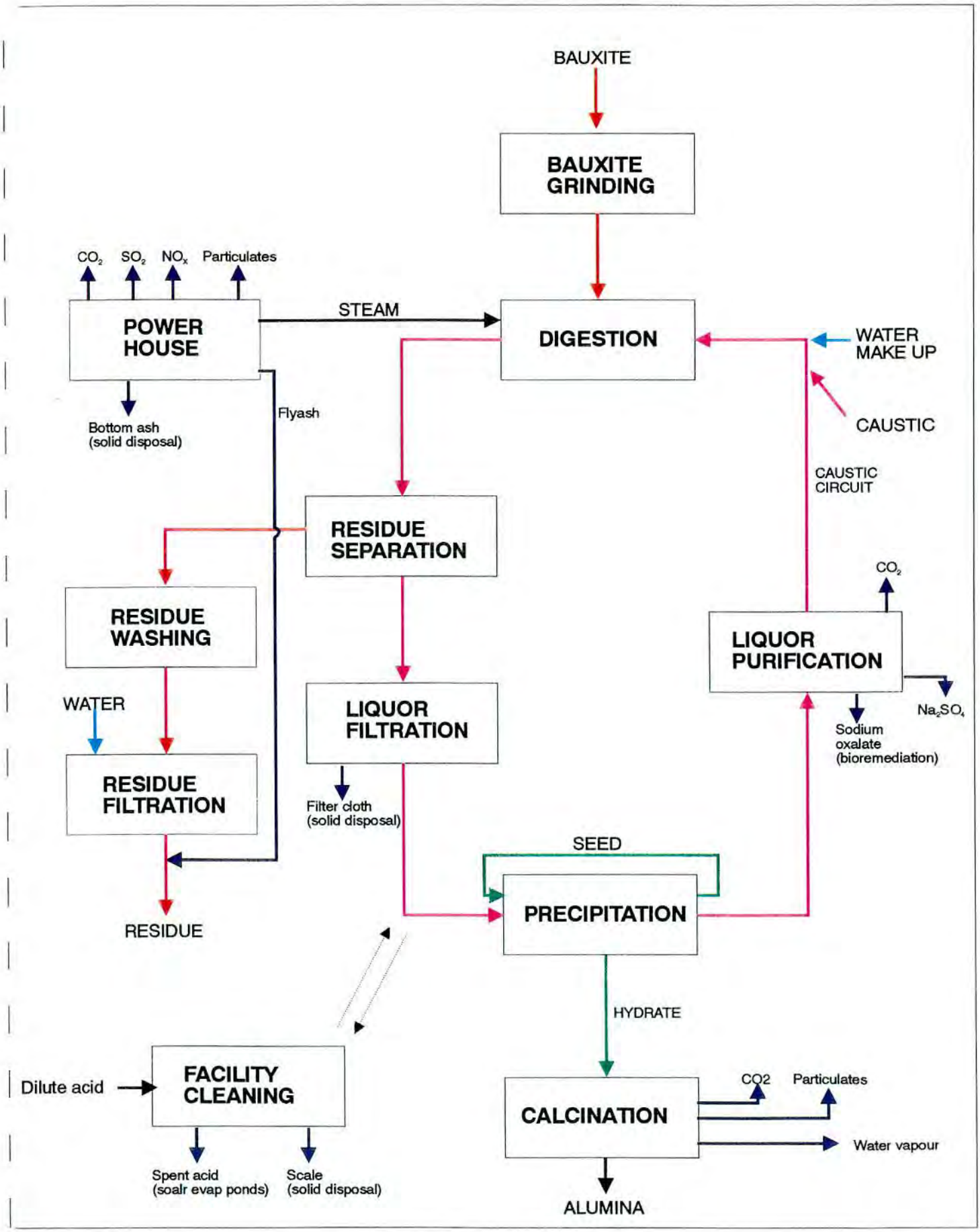



**Figure 11: Waste streams of the refinery operation**

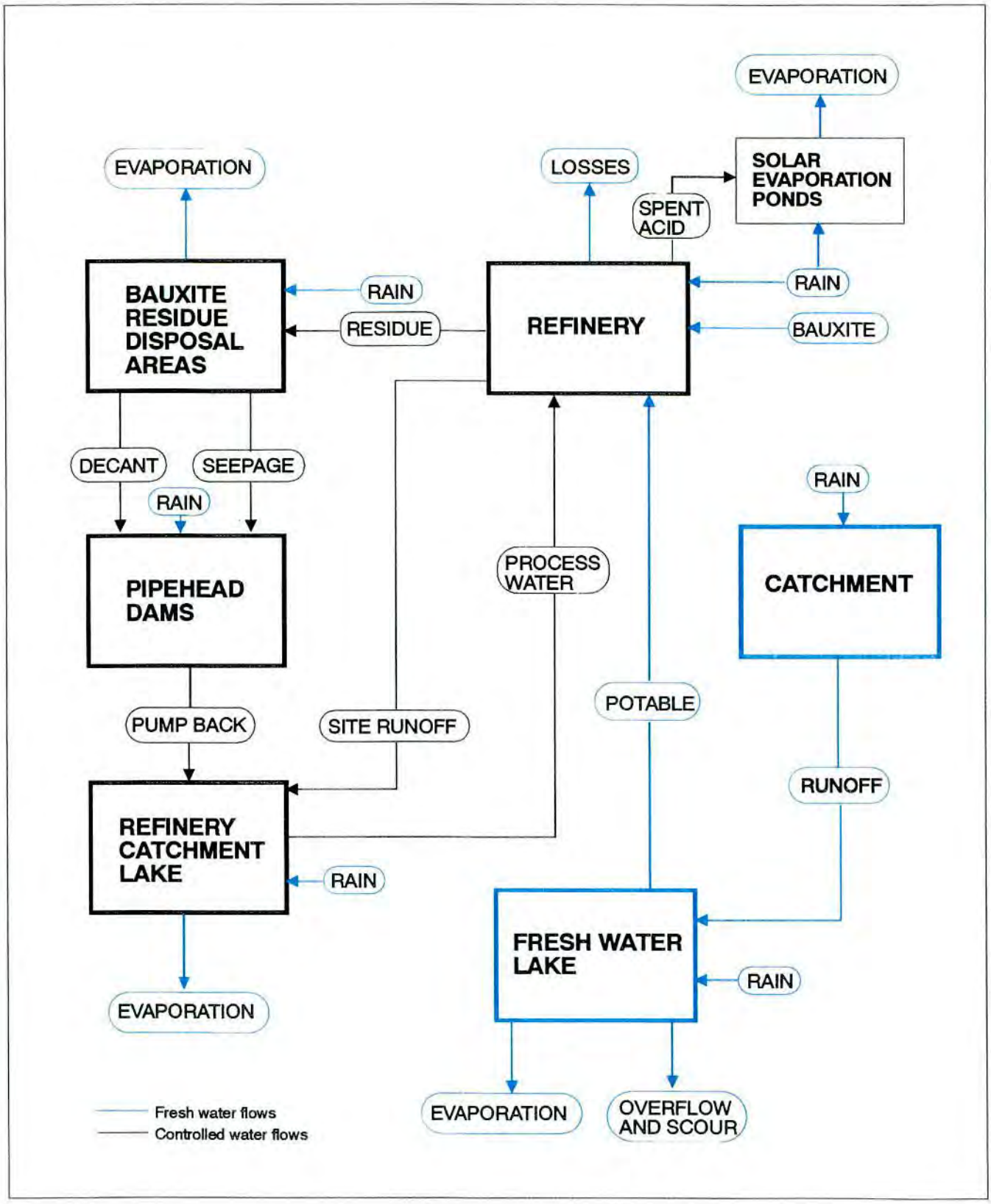



**Figure 12: Refinery water balance model**

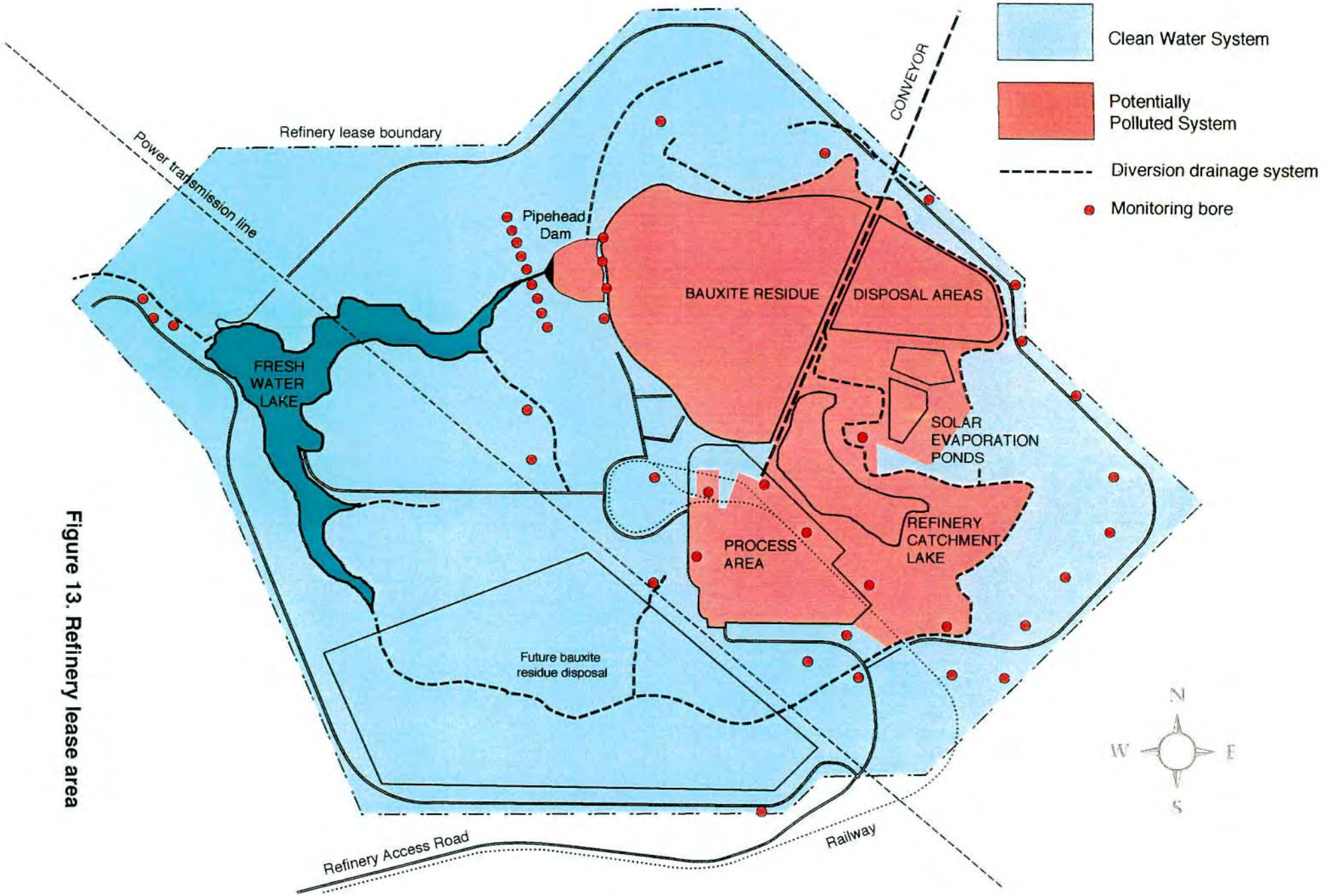



**Figure 13. Refinery lease area**

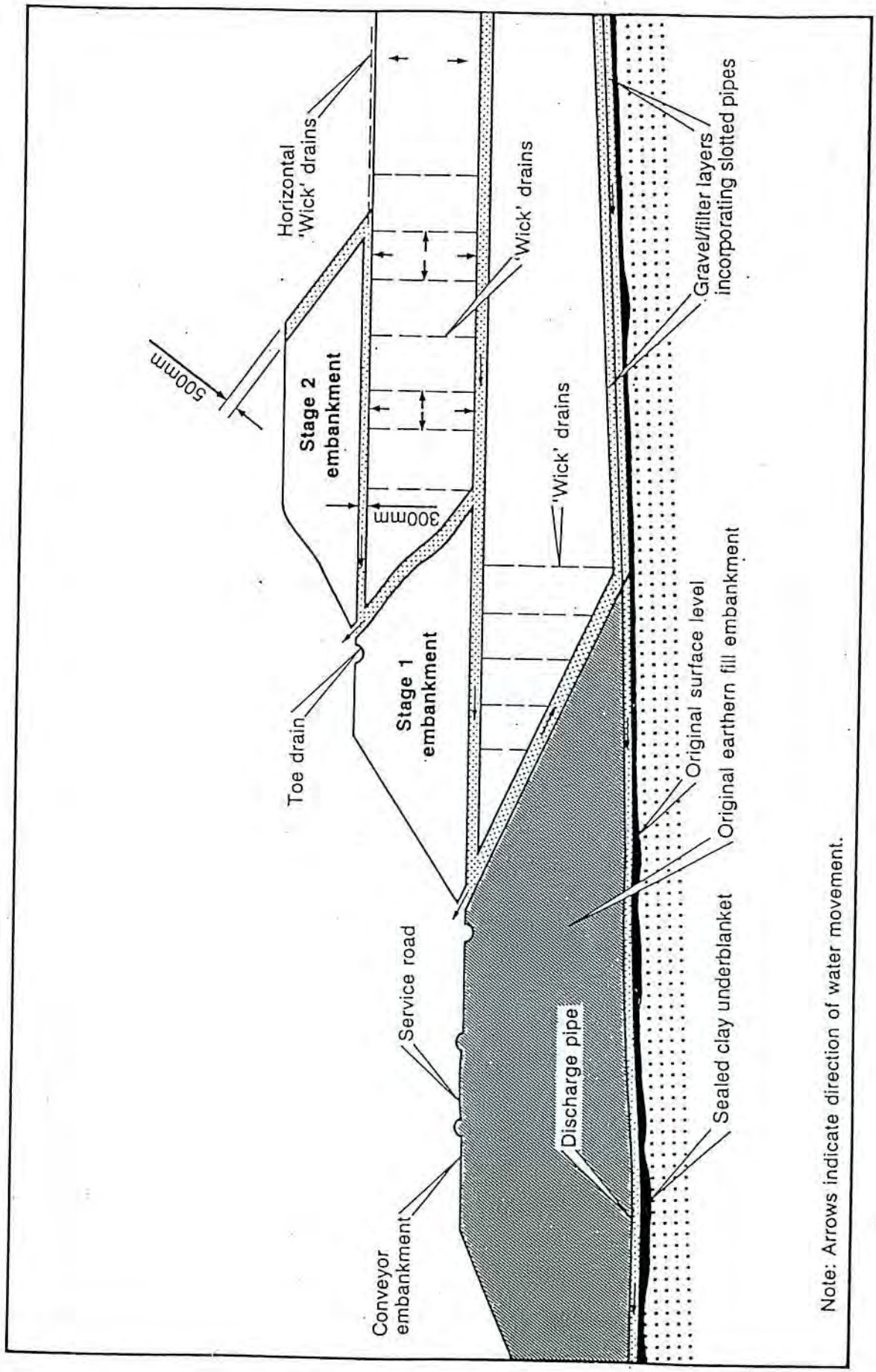



**Figure 14: Schematic cross-section of the BRDA's and under-drainage systems**

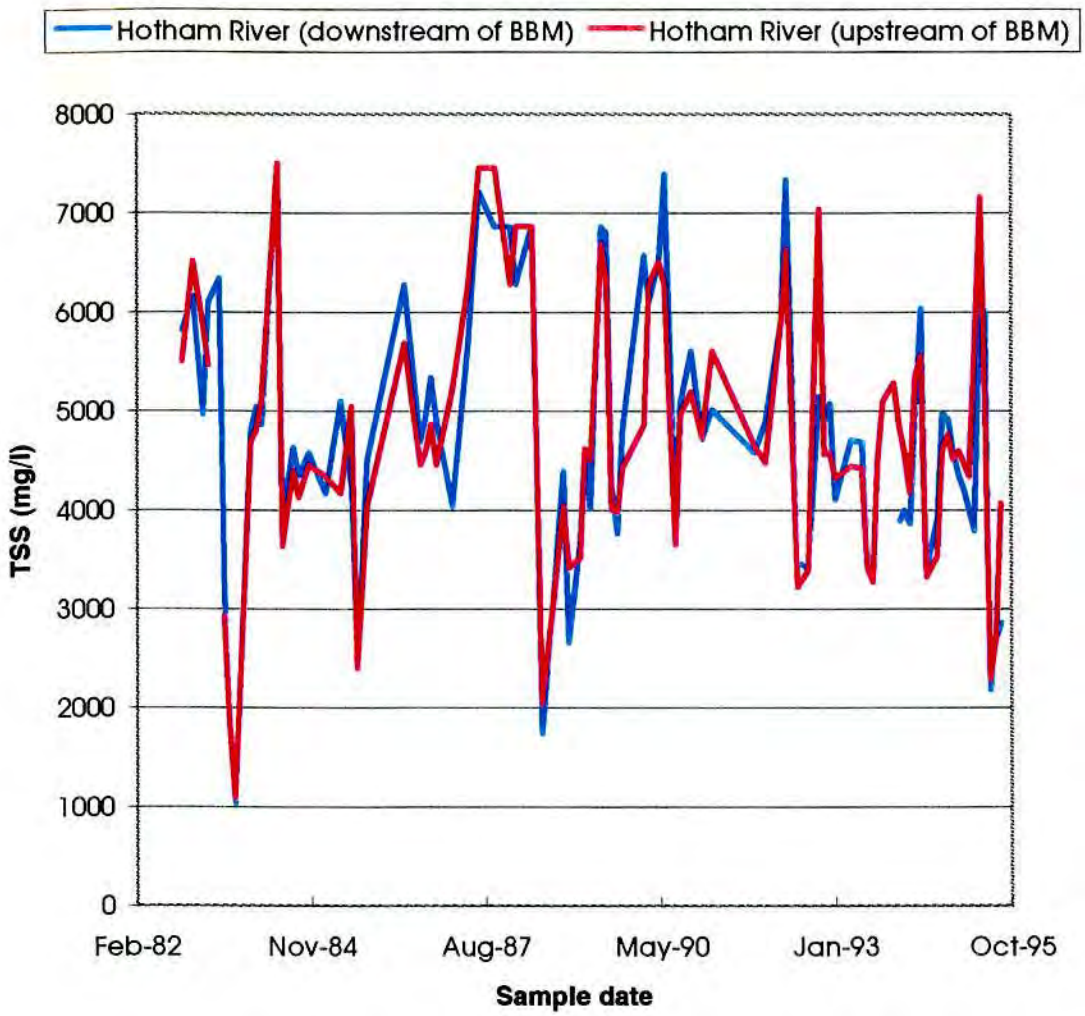



**Figure 15: Total soluble salts concentration - Hotham River 1982 - 1995**

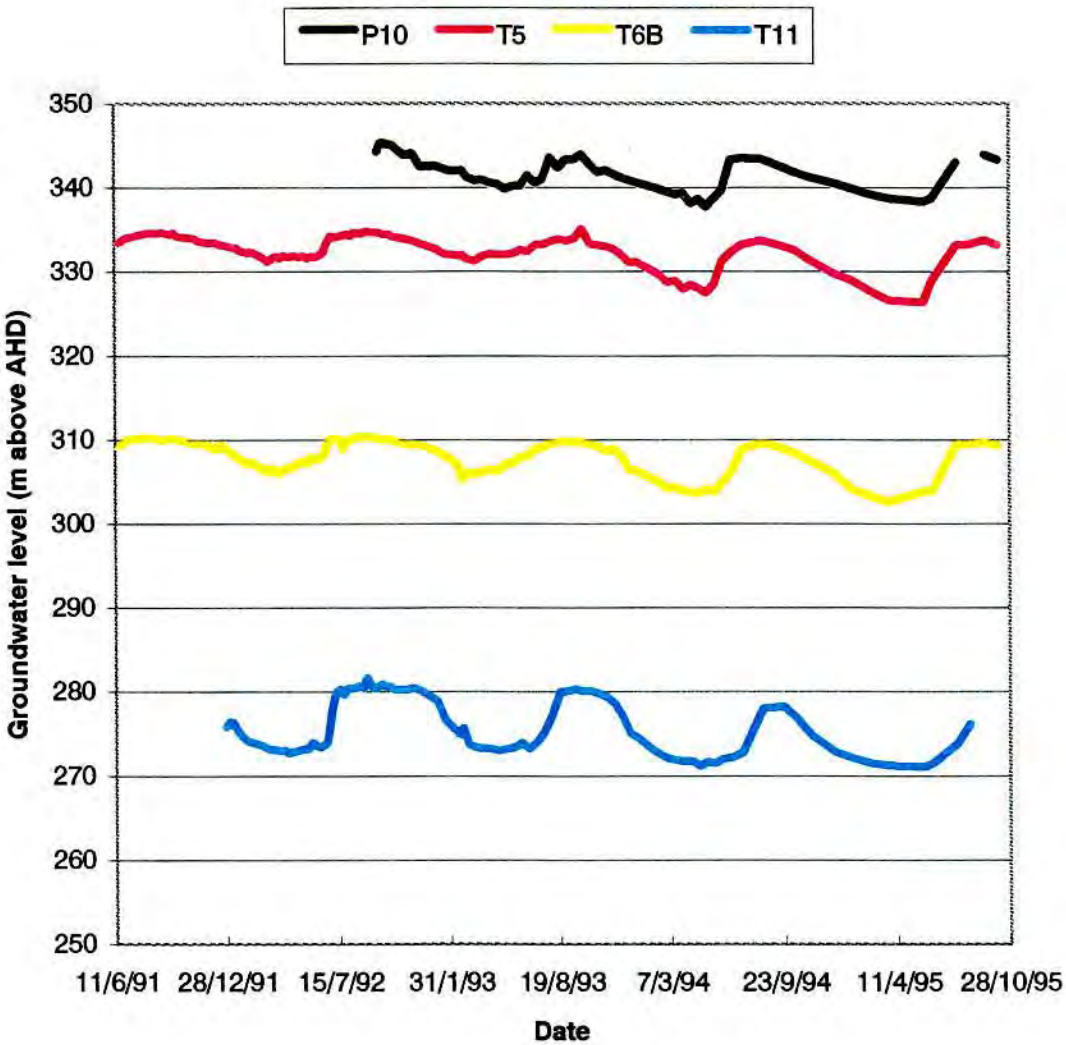
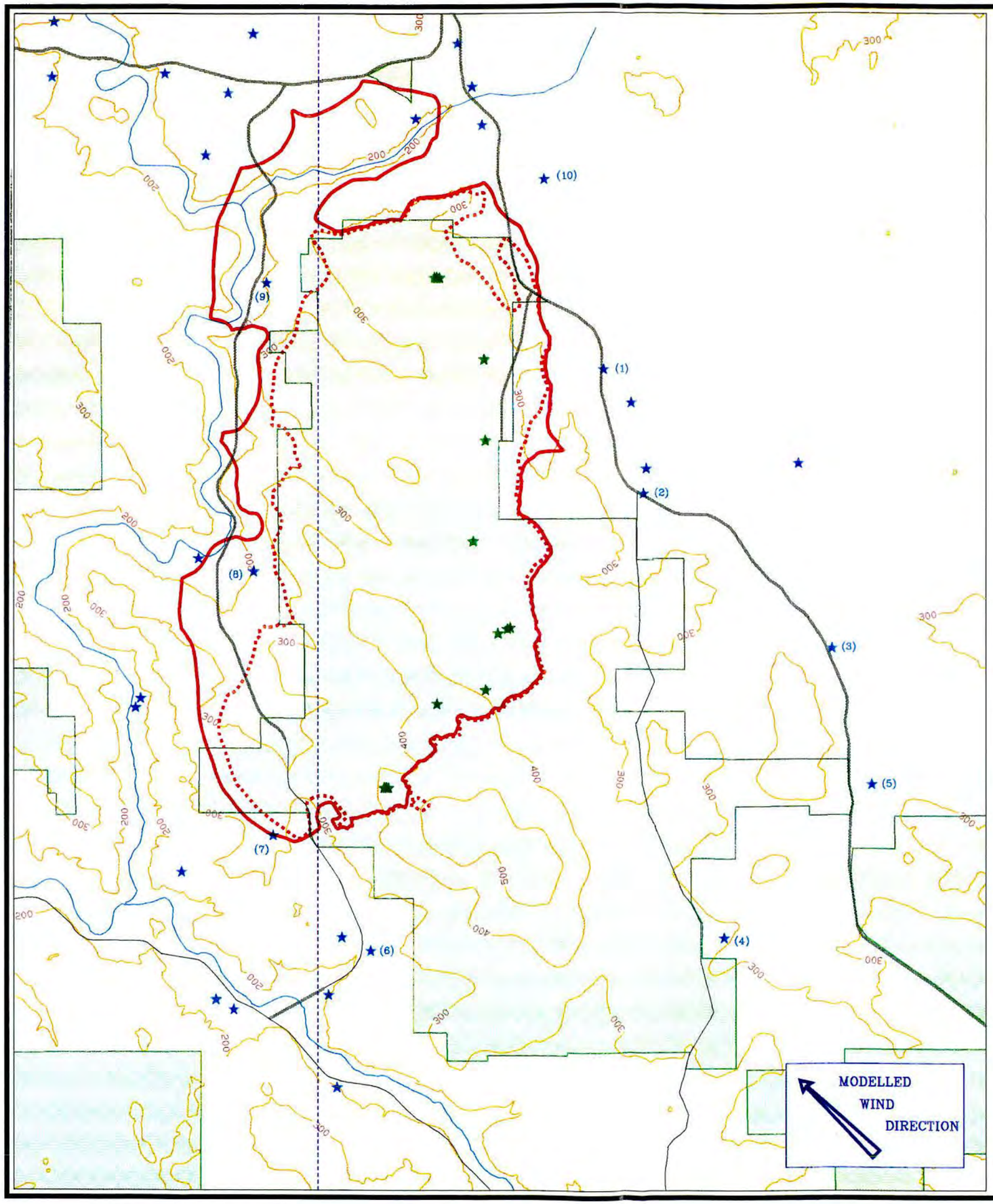



**Figure 16: Groundwater levels - Tunnell Road Borefield 1991-1995**





SCALE 1 : 60 000

1 0 1 2

KILOMETRES

## LEGEND

- 200 — 100m CONTOURS (AUSTRALIAN HEIGHT DATUM)
- SEALED/UNSEALED ROADS
- MINING LEASE 256SA BOUNDARY
- CROWN LAND
- ★ (1) RESIDENCES (LOCATIONS REFERENCED IN APPENDIX 6)
- ★ MODELLED SOURCES

## INPUTS

SOUND POWER LEVELS–dB(Lin)

| SOURCE | FREQUENCY BAND (Hz) | | | | | | | | | | OVERALL dB(A) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 22.5 TO 45 | 45 TO 90 | 90 TO 180 | 180 TO 355 | 355 TO 710 | 710 TO 1400 | 1400 TO 2800 | 2800 TO 5600 | 5600 TO 11200 | 11200 TO 22400 | |
| PRIMARY CRUSHER | 117 | 118 | 118 | 120 | 116 | 110 | 106 | 101 | 93 | 84 | 117 |
| SECONDARY CRUSHER | 117 | 116 | 117 | 117 | 116 | 107 | 106 | 103 | 99 | 94 | 116 |
| WHEELED LOADER | 98 | 106 | 111 | 111 | 108 | 106 | 103 | 99 | 94 | 88 | 111 |
| BACKHOE | 105 | 116 | 122 | 122 | 111 | 110 | 107 | 103 | 99 | 91 | 117 |
| TYPICAL TRUCK | 103 | 116 | 122 | 113 | 111 | 109 | 107 | 101 | 92 | 84 | 115 |

REMAINING NOISE SOURCES (9 OF 14) DETAILED IN APPENDIX 6

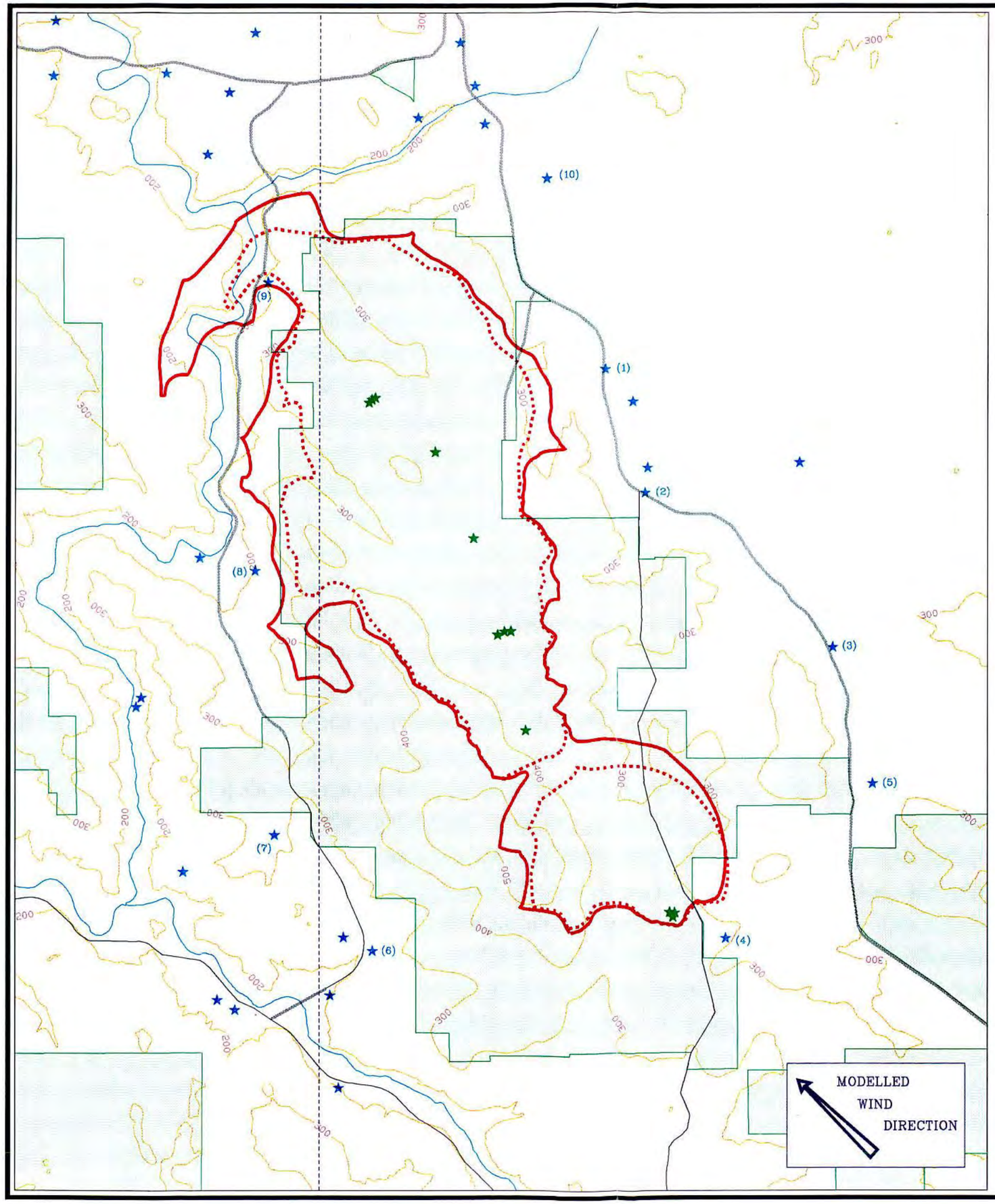
| | |
|---|---|
| TEMPERATURE | 7 °C |
| HUMIDITY | 69% |
| WIND SPEED | 3.0 and 4.0 m/sec (10m ABOVE GROUND) |
| WIND DIRECTION | 135 ° |
| GROUND TYPE | CLASS 4 (GRASS. ROUGH PASTURE) |

## OUTPUTS

ADJUSTED L10 35 dB(A) SOUND PRESSURE LEVEL CONTOUR

- 3.0 m/sec WIND SPEED
- 4.0 m/sec WIND SPEED

# MINING NOISE MODELLING
## TYPICAL OPERATION
## FIGURE 17





SCALE 1 : 60 000

1 0 1 2

KILOMETRES

## LEGEND

- 100m CONTOURS (AUSTRALIAN HEIGHT DATUM)
- SEALED/UNSEALED ROADS
- MINING LEASE 258SA BOUNDARY
- CROWN LAND
- ★ (1) RESIDENCES (LOCATIONS REFERENCED IN APPENDIX 8)
- ★ MODELLED SOURCES

## INPUTS

SOUND POWER LEVELS–dB(Lin)

| SOURCE | FREQUENCY BAND (Hz) | | | | | | | | | | OVERALL dB(A) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 22.5 TO 45 | 45 TO 90 | 90 TO 180 | 180 TO 355 | 355 TO 710 | 710 TO 1400 | 1400 TO 2800 | 2800 TO 5600 | 5600 TO 11200 | 11200 TO 22400 | |
| PRIMARY CRUSHER | 117 | 118 | 118 | 120 | 116 | 110 | 106 | 101 | 93 | 84 | 117 |
| SECONDARY CRUSHER | 117 | 116 | 117 | 117 | 116 | 107 | 108 | 103 | 99 | 94 | 116 |
| WHEELED LOADER | 98 | 108 | 111 | 111 | 108 | 106 | 103 | 99 | 94 | 88 | 111 |
| BACKHOE | 105 | 116 | 122 | 122 | 111 | 110 | 107 | 103 | 99 | 91 | 117 |
| TYPICAL TRUCK | 103 | 118 | 122 | 113 | 111 | 109 | 107 | 101 | 92 | 84 | 115 |

REMAINING NOISE SOURCES (7 OF 12) DETAILED IN APPENDIX 6

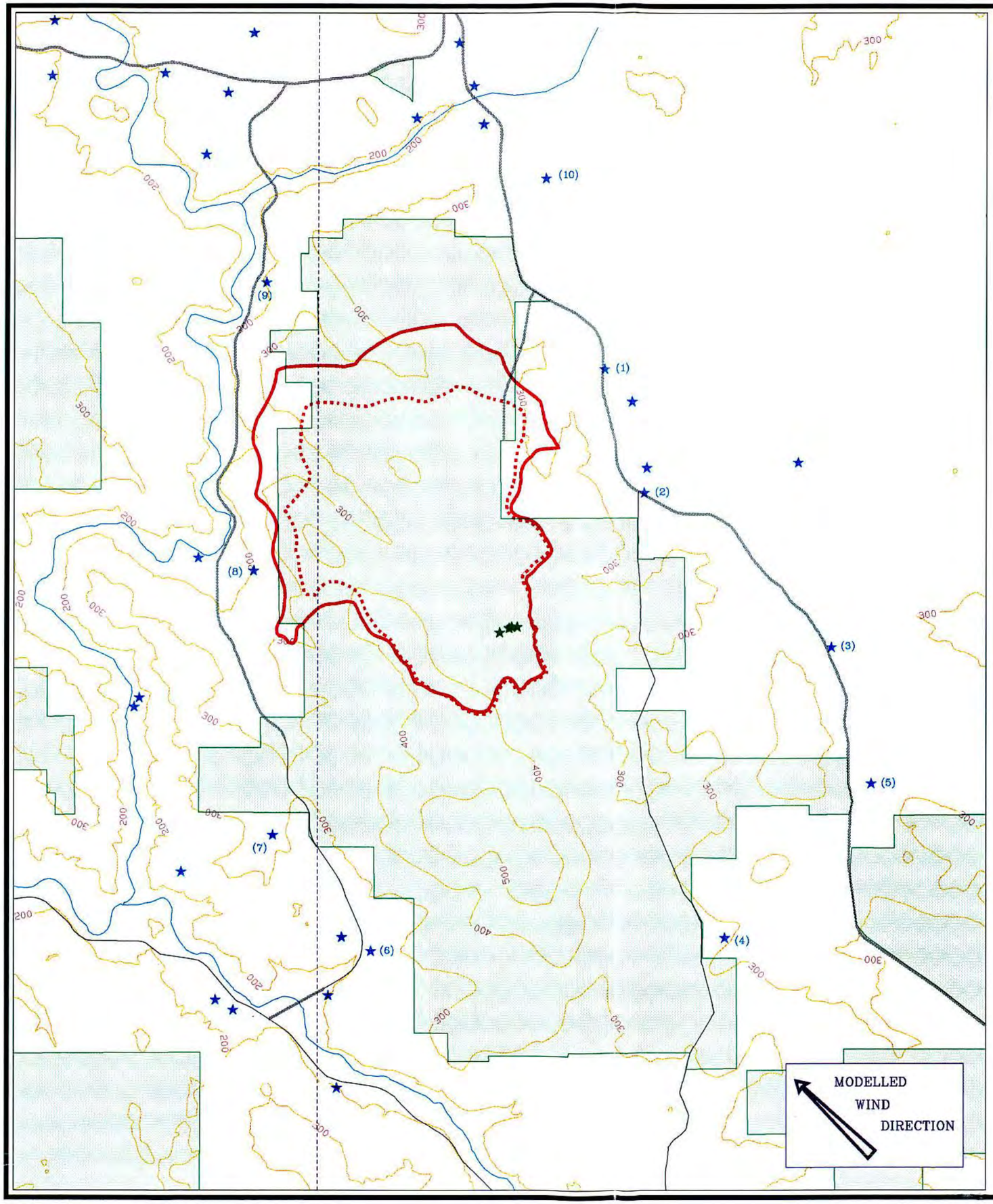
| | |
|---|---|
| TEMPERATURE | 7 °C |
| HUMIDITY | 69% |
| WIND SPEED | 3.0 and 4.0 m/sec (10m ABOVE GROUND) |
| WIND DIRECTION | 135 ° |
| GROUND TYPE | CLASS 4 (GRASS, ROUGH PASTURE) |

## OUTPUTS

ADJUSTED L10 35 dB(A) SOUND PRESSURE LEVEL CONTOUR

- 3.0 m/sec WIND SPEED
- 4.0 m/sec WIND SPEED

# MINING NOISE MODELLING
## CORE OPERATION
## FIGURE 18





SCALE 1 : 60 000

1 0 1 2

KILOMETRES

## LEGEND

- 100m CONTOURS (AUSTRALIAN HEIGHT DATUM)
- SEALED/UNSEALED ROADS
- MINING LEASE 258SA BOUNDARY
- CROWN LAND
- ★ (1) RESIDENCES (LOCATIONS REFERENCED IN APPENDIX 8)
- ★ MODELLED SOURCES

## INPUTS

SOUND POWER LEVELS–dB(Lin)

| SOURCE | FREQUENCY BAND (Hz) | | | | | | | | | | OVERALL dB(A) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 22.5 TO 45 | 45 TO 90 | 90 TO 180 | 180 TO 355 | 355 TO 710 | 710 TO 1400 | 1400 TO 2800 | 2800 TO 5600 | 5600 TO 11200 | 11200 TO 22400 | |
| PRIMARY CRUSHER | 117 | 116 | 116 | 120 | 116 | 110 | 106 | 101 | 93 | 84 | 117 |
| SECONDARY CRUSHER | 117 | 116 | 117 | 117 | 116 | 107 | 106 | 103 | 99 | 94 | 116 |
| WHEELED LOADER | 98 | 108 | 111 | 111 | 106 | 106 | 103 | 99 | 94 | 88 | 111 |
| WHEELED LOADER | 98 | 108 | 111 | 111 | 106 | 106 | 103 | 99 | 94 | 88 | 111 |

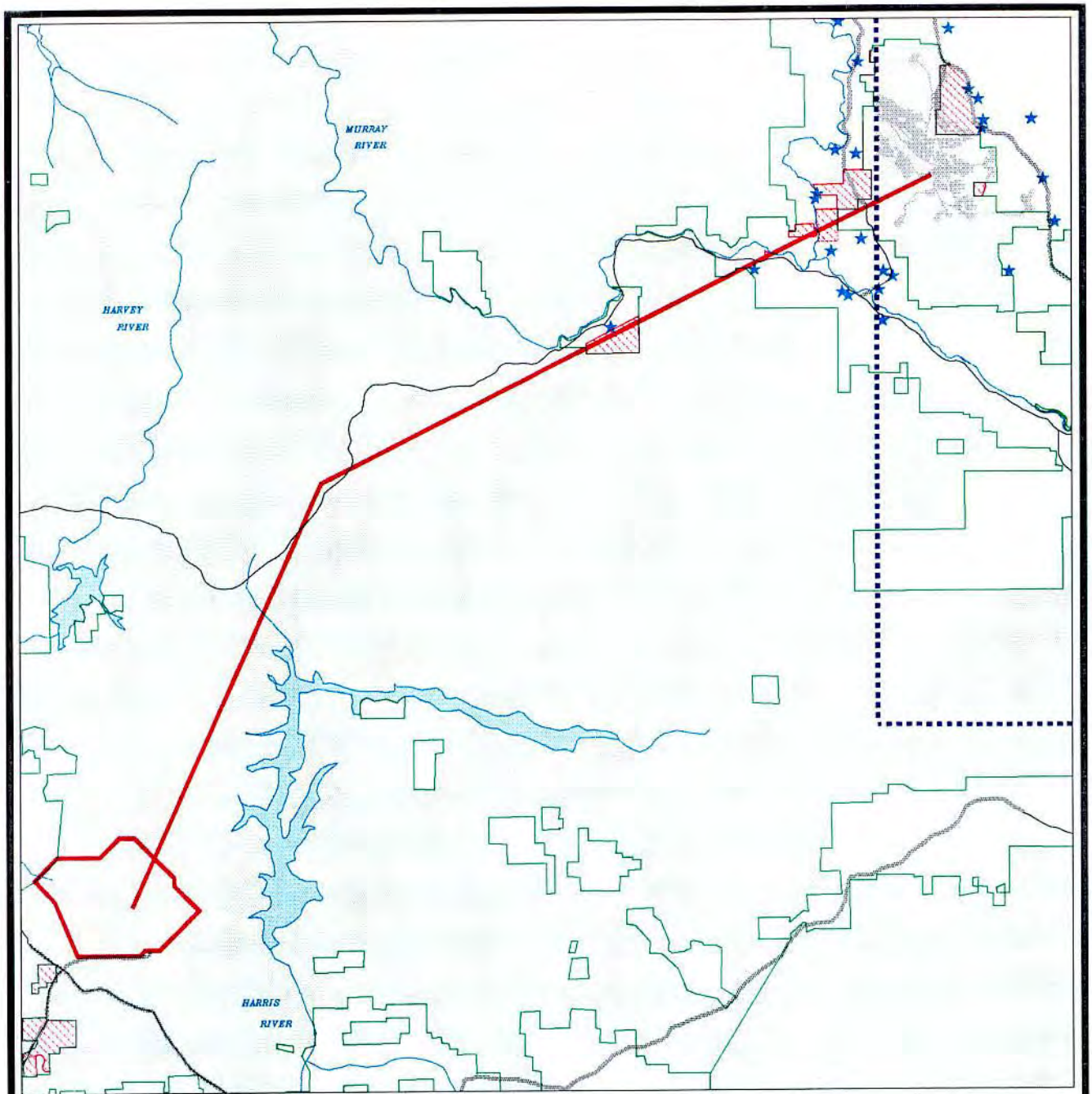
| | |
|---|---|
| TEMPERATURE | 7 °C |
| HUMIDITY | 69% |
| WIND SPEED | 3.0 and 4.0 m/sec (10m ABOVE GROUND) |
| WIND DIRECTION | 135 ° |
| GROUND TYPE | CLASS 4 (GRASS. ROUGH PASTURE) |

## OUTPUTS

ADJUSTED L10 35 dB(A) SOUND PRESSURE LEVEL CONTOUR

- 3.0 m/sec WIND SPEED
- 4.0 m/sec WIND SPEED

# MINING NOISE MODELLING
## NIGHTSHIFT FALLBACK OPTION
## FIGURE 19




LEGEND

SEALED/UNSEALED ROADS

CROWN LAND

PRIVATE LAND MANAGED
BY WORSLEY

MINING LEASE 258SA BOUNDARY

RESIDENCES NEAR THE MINESITE
AND CONVEYOR

N

SCALE 1 : 275 000

5 0 5 10

KILOMETRES

# OVERLAND CONVEYOR ROUTE

FIGURE 20

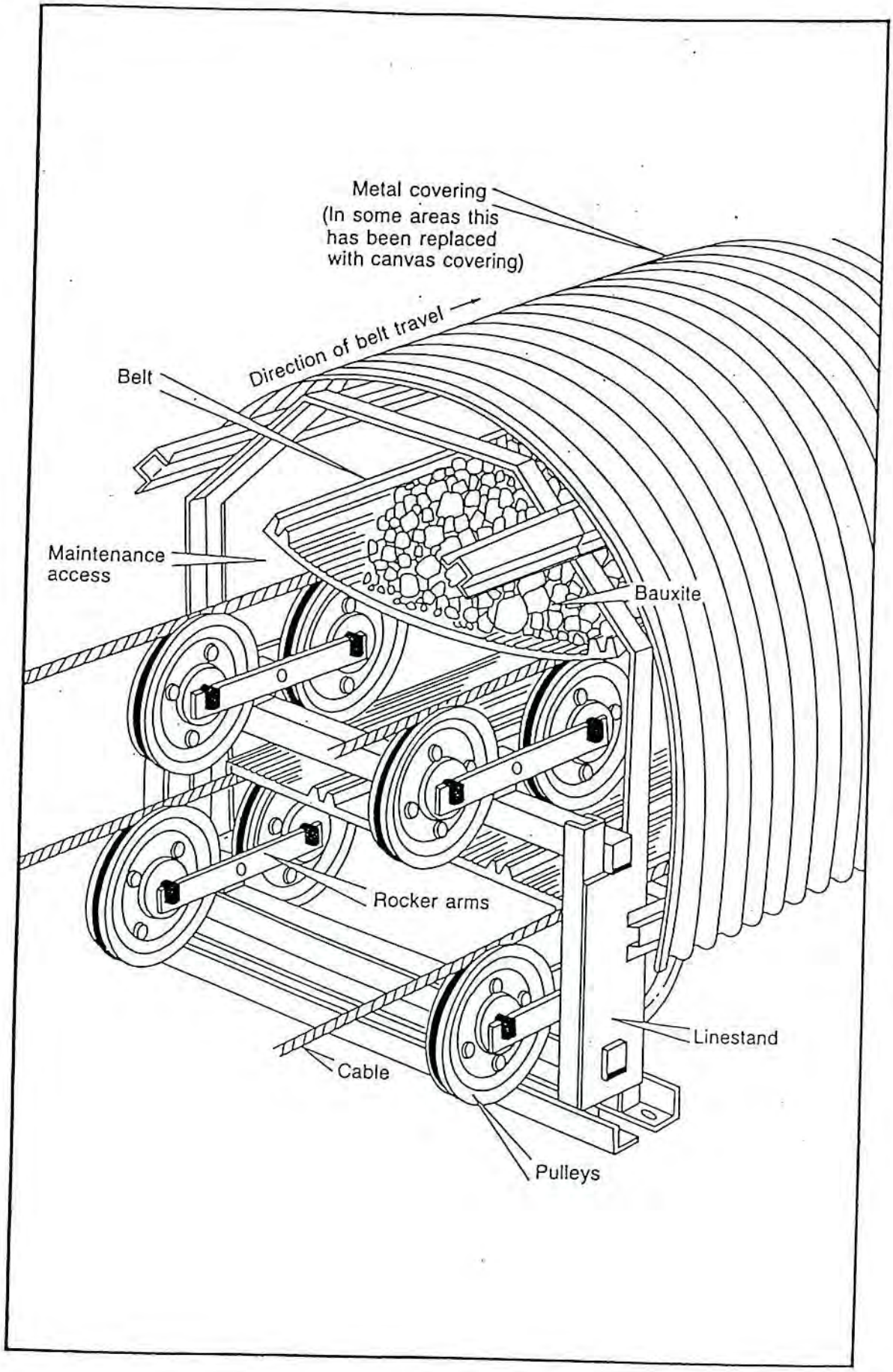



**Figure 21: Schematic cross-section of the conveyor**

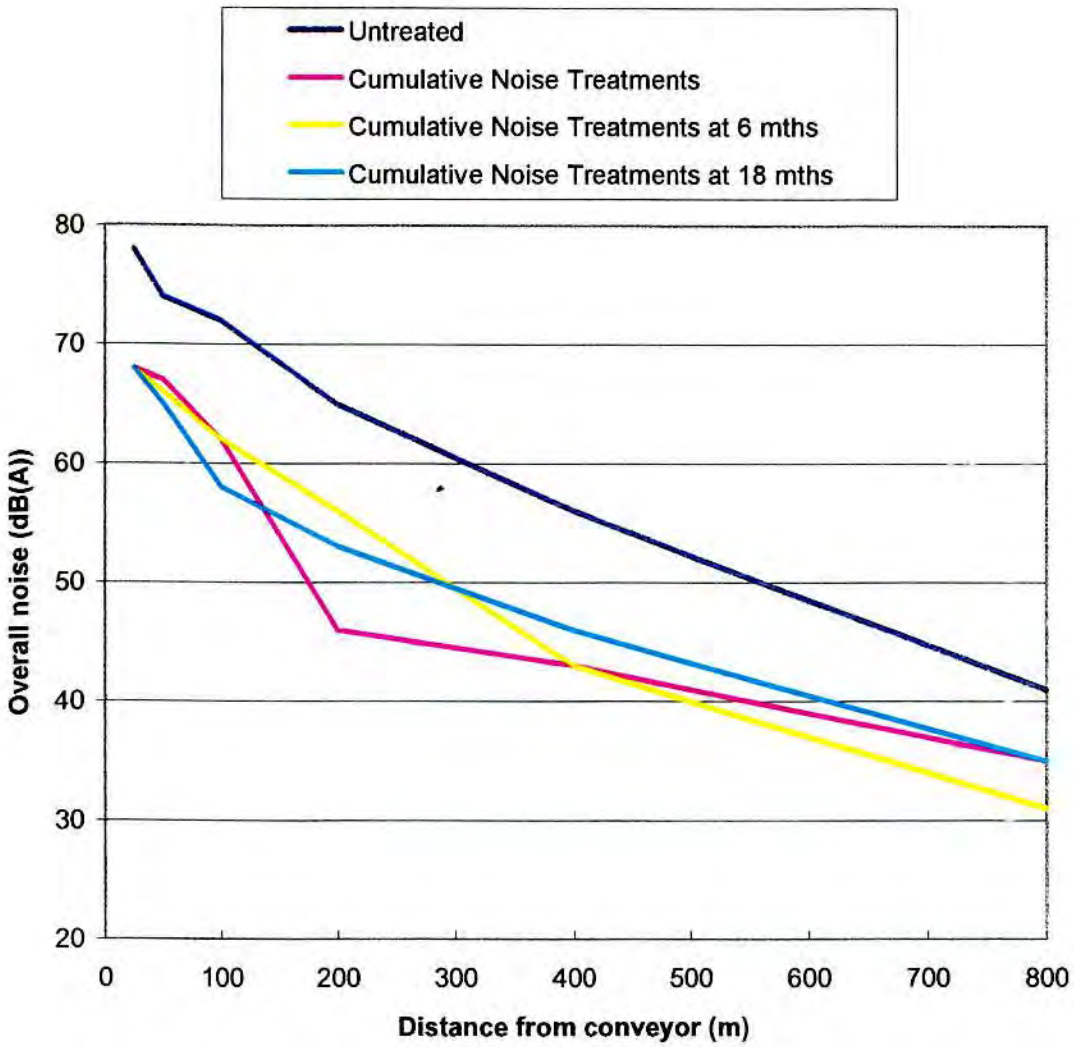



**Figure 22: Noise decay curve from the overland conveyor (Lower Hotham Road)**

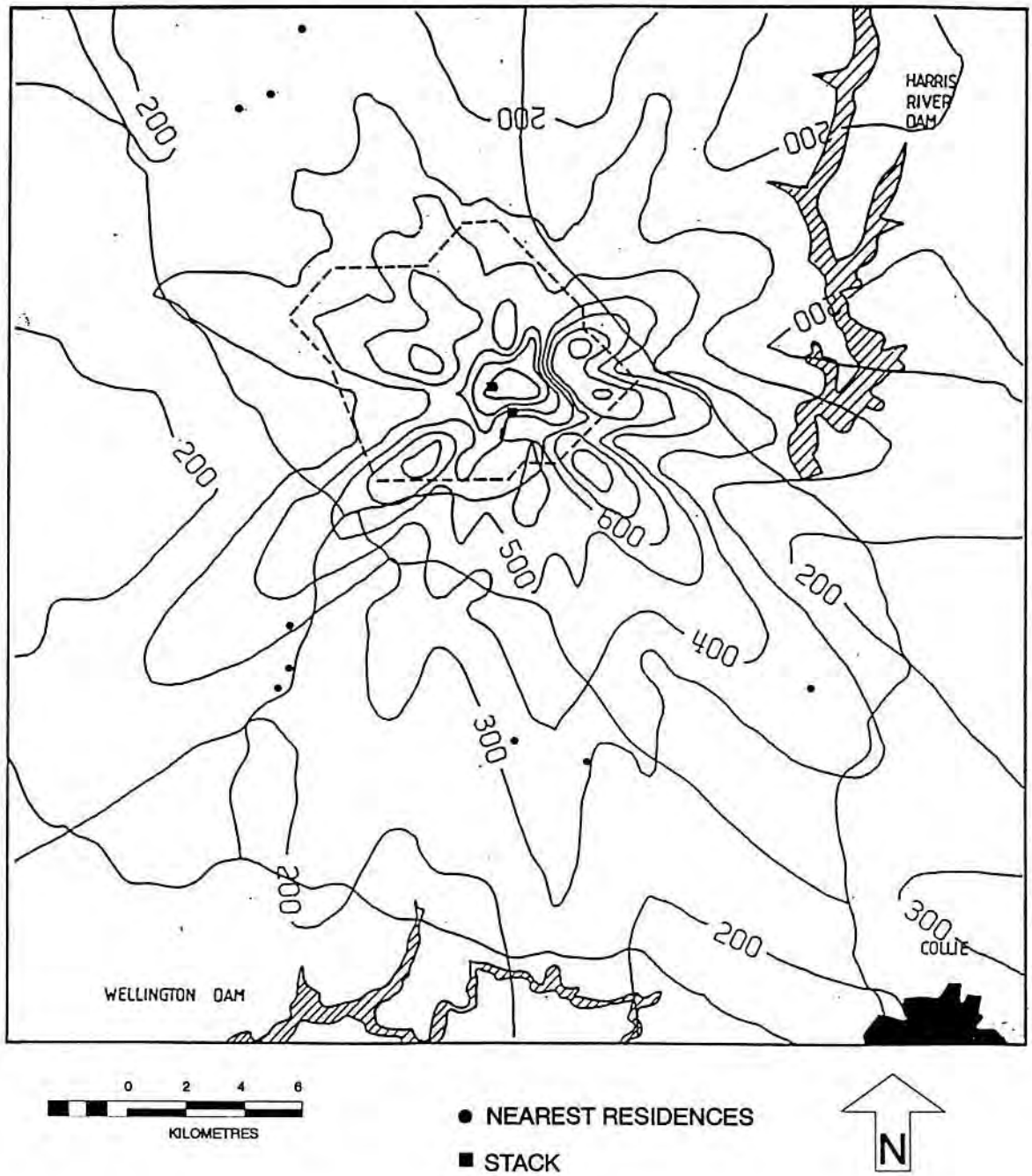



**Figure 23: Predicted maximum one hourly average ground level concentration of $SO_2$ from the Worsley refinery and Muja and proposed Collie power stations.**

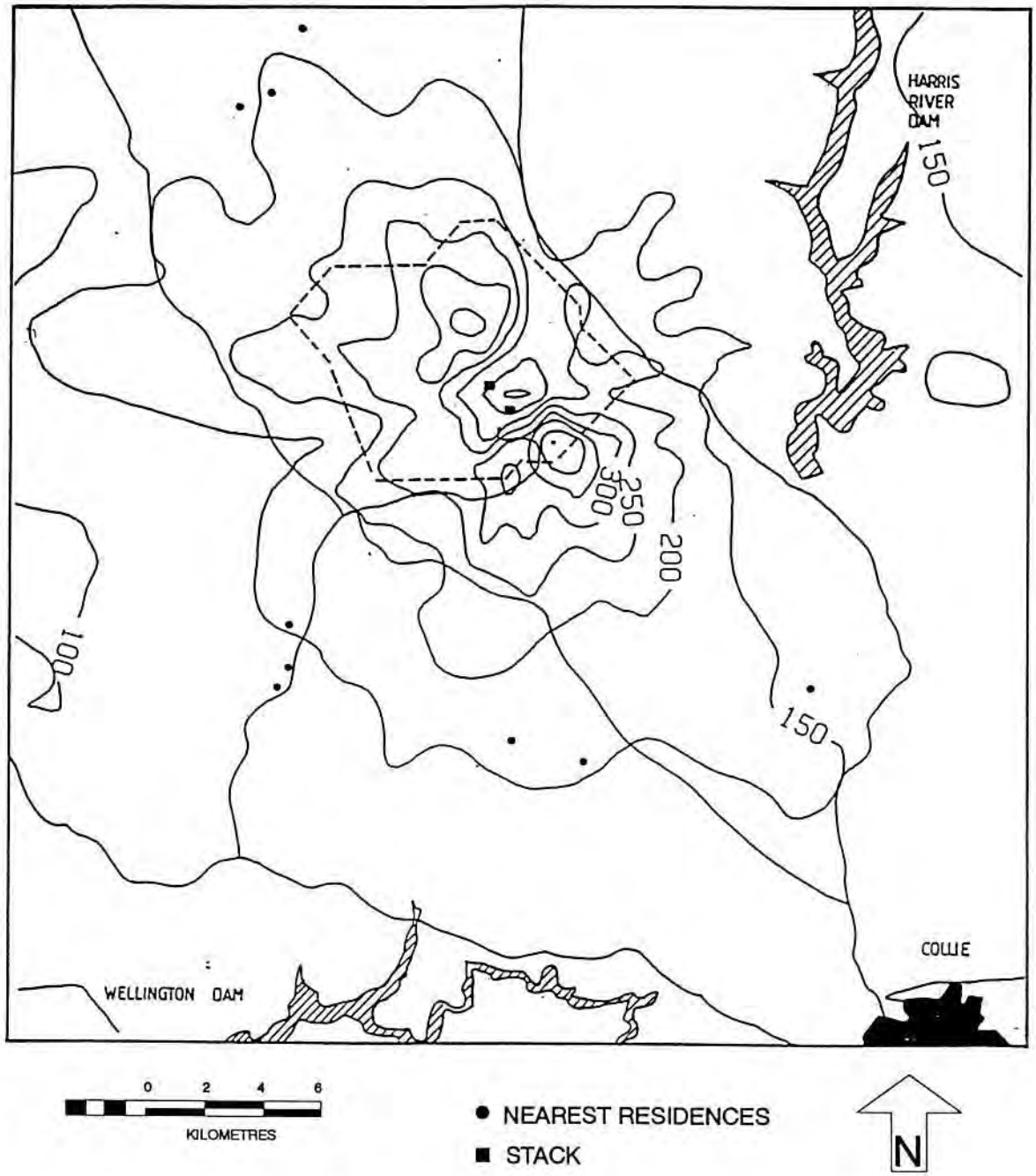



**Figure 24: Predicted 9th highest one hourly average ground level concentration of $SO_2$ from the Worsley refinery and Muja and proposed Collie power stations.**

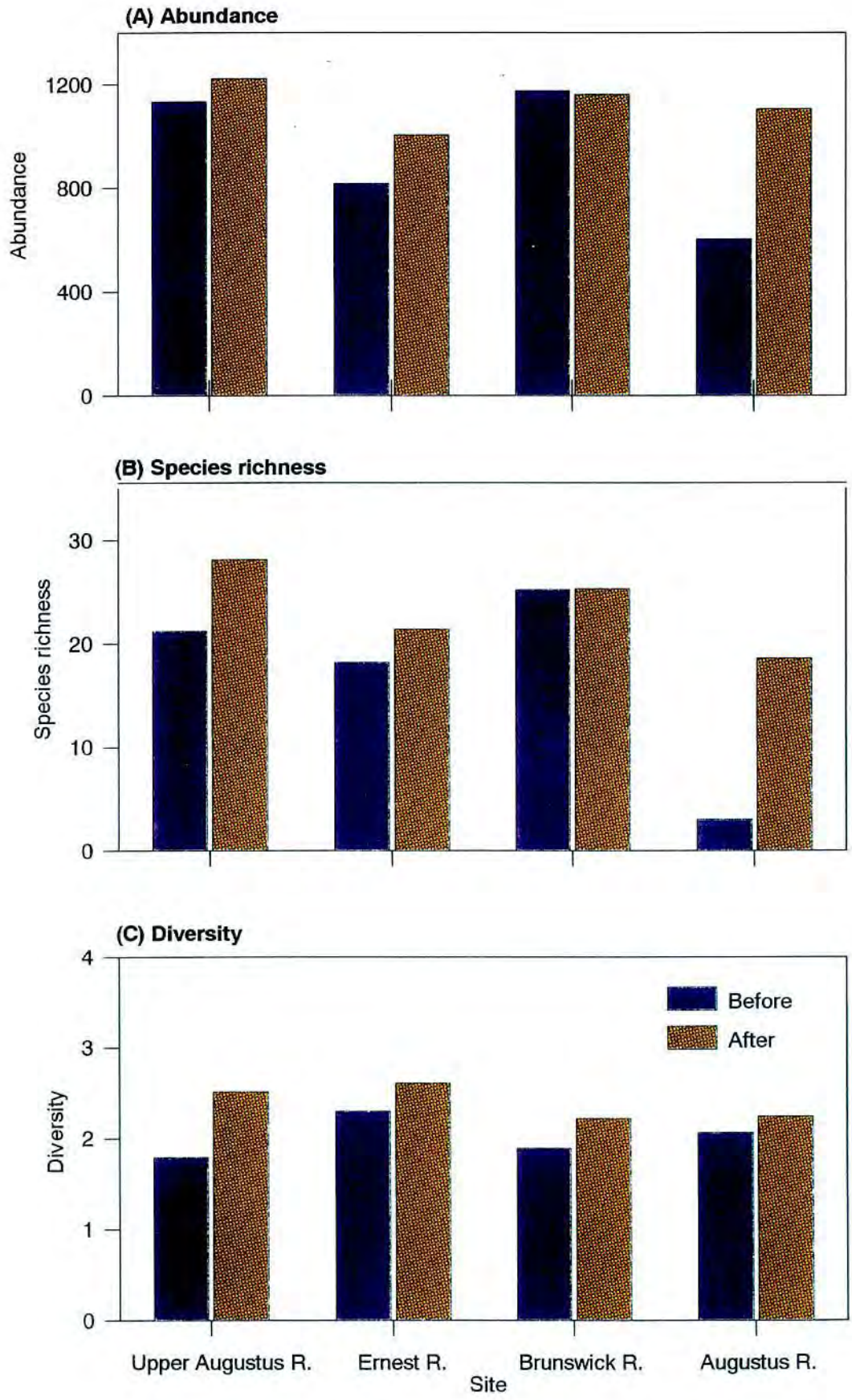



**Figure 25: Macroinvertebrate abundance, species richness and diversity at Augustus, Brunswick and Ernest Rivers.**

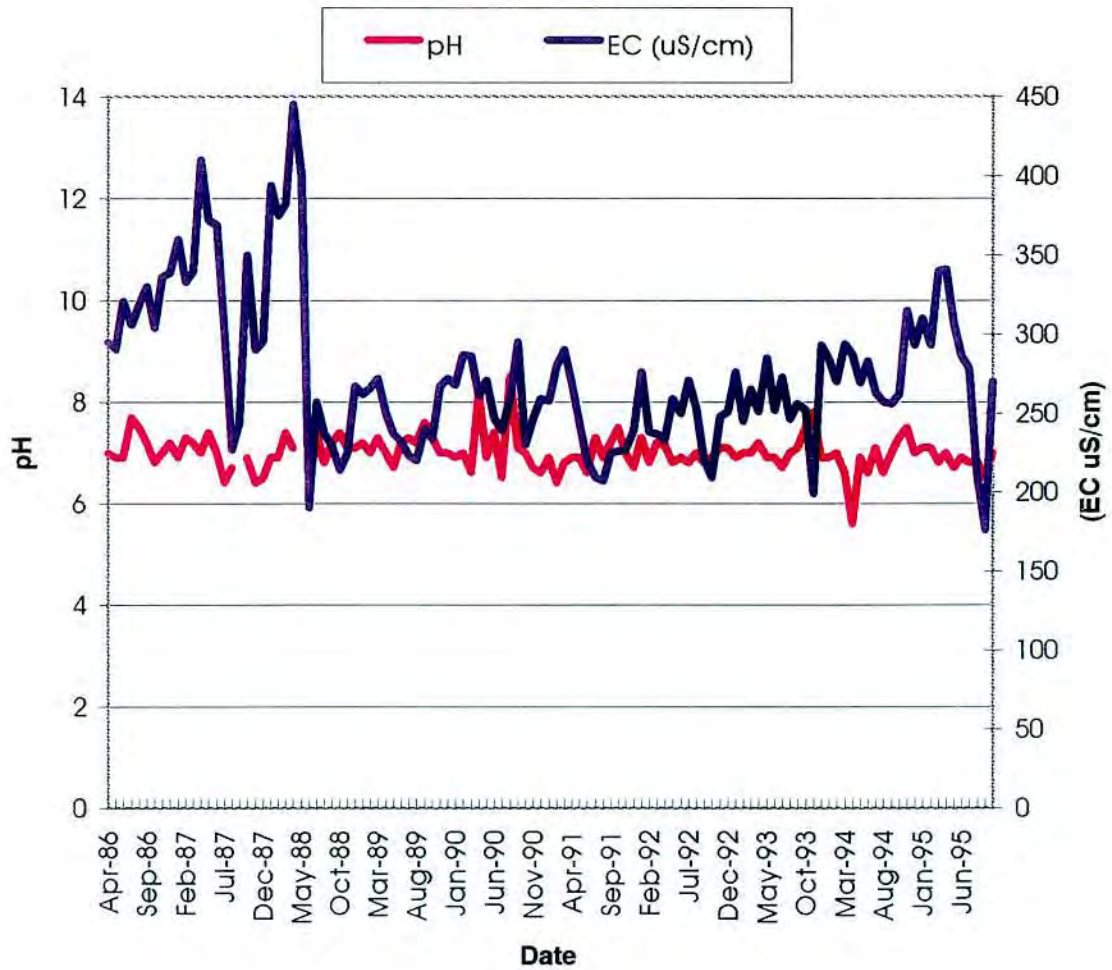



**Figure 26: Water quality measured at Augustus River gauging station 1986-1995**

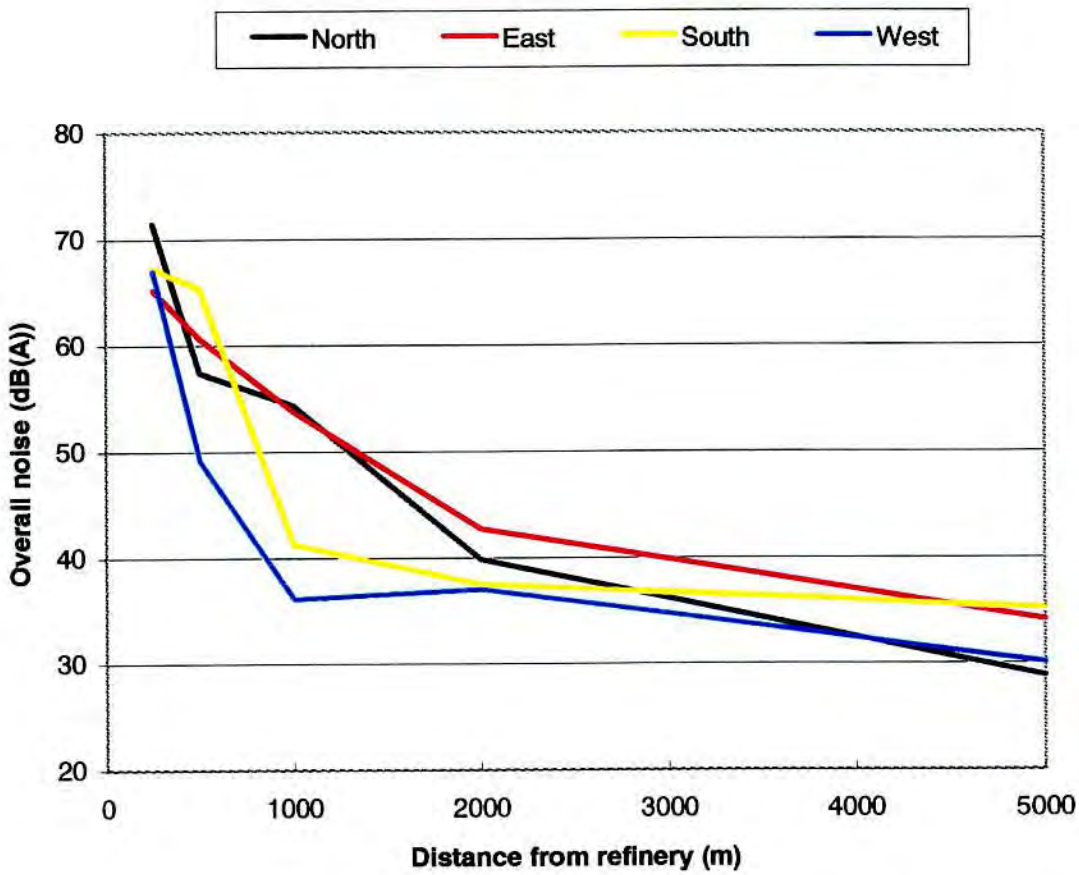
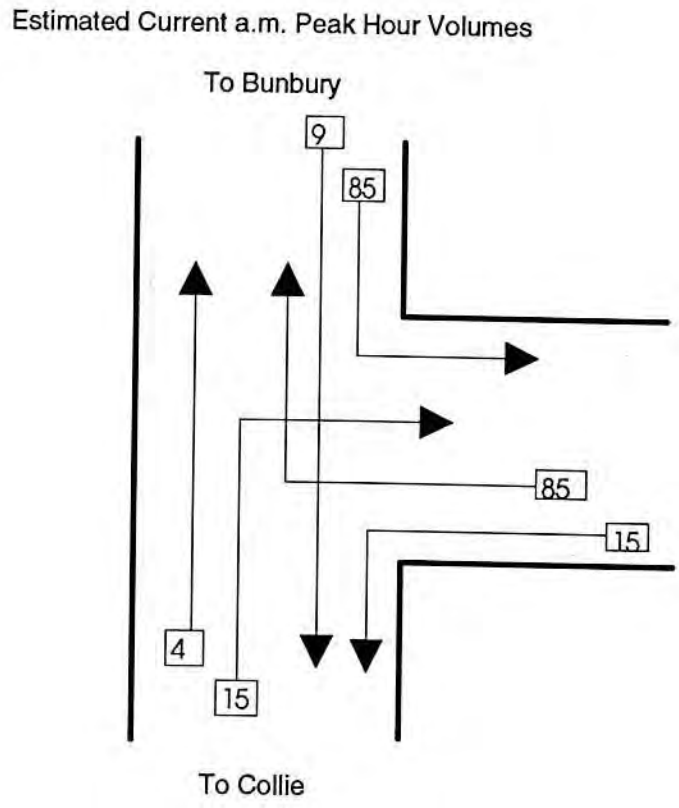



**Figure 27: Radial Noise measurements from the refinery**



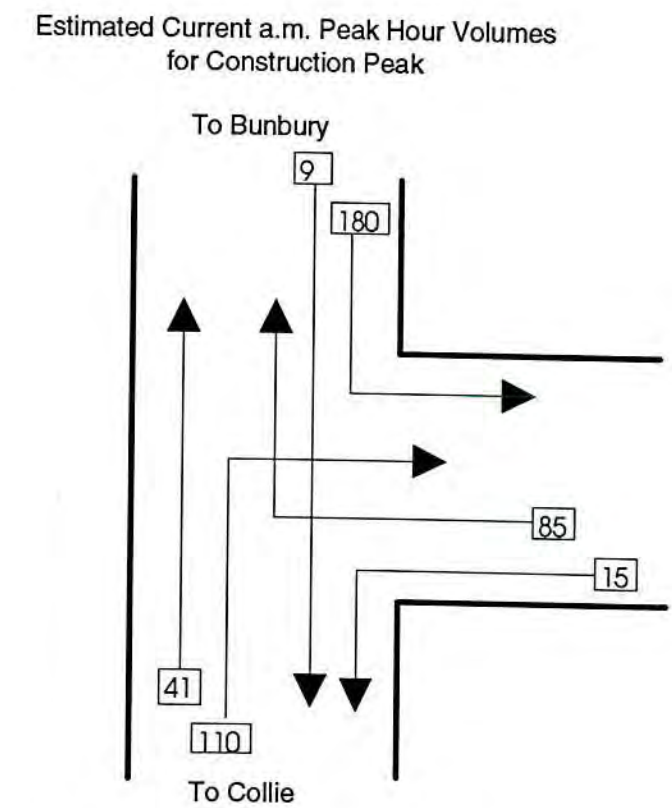




**Figure 28: Estimated a.m. Peak Hour Traffic Volumes at Coalfields and Gestaldo Road Intersection.**

# APPENDIX 1

# WORSLEY ALUMINA EXPANSION
# CER GUIDELINES

# EXPANSION OF ALUMINA PRODUCTION FROM 2.0 MILLION TPA TO 3.5 MILLION TPA AT WORSLEY AND ASSOCIATED BAUXITE MINING ACTIVITIES AT BODDINGTON BY WORSLEY ALUMINA PTY LTD (ASSESSMENT NO. 984)

## GUIDELINES FOR THE ENVIRONMENTAL IMPACT ASSESSMENT DOCUMENT (CER)

### OVERVIEW

The Environmental Protection Authority (EPA) understands that this proposal is to increase alumina production from 2,000,000 t/a to 3,500,000 tonnes per annum. The project was previously assessed by the EPA in 1979 (Bulletin 56).

Environmental reviews have the objective of protecting the environment, and environmental impact assessment involves a public process to obtain a wide range of input from the community and government agencies. The review requires the proponent Worsley Alumina Pty Ltd (Worsley) to describe the proposal, receiving environment, potential environmental impacts and the management of the topics arising from the environmental impacts, so that the environment is protected to an acceptable level in the best manner possible.

Throughout the process, it is the objective of the Department of Environmental Protection (DEP) to assist Worsley to improve the proposal such that the environment is protected to an acceptable level in the best manner possible. The DEP would coordinate relevant government agencies and the public in providing advice about environmental matters during the assessment of the document.

These guidelines are issued to assist in identifying matters that should be addressed within the CER document. They are not exhaustive and other relevant issues may arise during the preparation of the document; these should also be included in the document.

### PURPOSE OF THE CER DOCUMENT

The emphasis of the environmental review should be to:

- describe the proposal adequately so that the Minister for the Environment can consider approval of a well-defined project;
- demonstrate that the environmental issues addressed in the 1979 EPA assessment report are being presently managed in an environmentally acceptable manner (compliance with environmental approvals);
- provide the basis of Worsley's environmental management strategy to show that the environmental topics resulting from the expansion can be acceptably managed; and
- communicate clearly with the public (including Government agencies) so that the EPA can obtain informed comment to assist in providing advice to Government.

The CER should facilitate public review of the key environmental topics in the main body of the text and should be in terms which are understandable (simple and concise) to the general public. Detailed specialist and technical information should be placed in appendices. As the CER forms the legal basis for the approval of the Minister for the Environment, it should be lucid.

Where specific information has been requested by a Government department or the local authority this should be included in the document.

A copy of these guidelines should appear in the CER document.

## KEY TOPICS AND SCOPING

The key topics can be determined from a consideration (called scoping) of the potential impacts from the various components of the proposal on a receiving environment, including people. For this proposal they are the similar to the issues as outlined for the 1979 EPA assessment. A description of the project component and the receiving environment should be directly included with, or referenced to, the discussion of the key topics. The technical basis for measuring the impact and any objectives or standards for assessing and managing the issues should be provided. The key topics are outlined later.

## BEST PRACTICE ENVIRONMENTAL MANAGEMENT

The EPA considers that the proponent should approach environmental management in terms of best practise. Worsley should demonstrate that techniques used and methods proposed in the upgrading proposal incorporate best practice environmental management (the concept of "best practice" implies the use of the best practicable equipment, processes, systems and techniques and a commitment to management practices to achieve continuous improvement in regard to managing environmental impacts).

Best practice environmental management includes:

- development of an environmental policy;
- agreed environmental objectives;
- management of the environmental objectives;
- involve the public as appropriate;
- audit environmental performance against agreed indicators;
- regular reporting to the EPA (or nominated agency);
- commitment to a quality assured management system and continuous improvement;
- periodic (for example 5 yearly) review in conjunction with EPA (or nominated agency).

The proponent should provide a table which describes the following:

(a) the present state of the environment;
(b) potential impacts of the proposal on the environment;
(c) nominate environmental management objective(s) for those aspects which require management;
(d) environmental management response to manage impacts to meet the above objective(s); and
(e) envisaged resultant state of the environment

under three major headings:

- biophysical environment
- pollution potential
- social surroundings.

## PUBLIC CONSULTATION

A description should be provided of public consultation activities undertaken by the proponent in preparing the CER. This should outline the activities, the groups or individuals involved and the objectives of the activities. A summary of concerns raised should be documented along with how each of these concerns has been addressed.

Cross reference should be made with the description of environmental management of the issues which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

## CONTENTS OF CER

### *SUMMARY*

The CER document should contain a brief summary of:

- salient features of the proposal;
- summary description of anticipated changes to raw materials and energy usage, operations and process technology;
- brief description of the local receiving environment and potential impacts of the proposal thereon;
- environmental monitoring and management programs, safeguards and commitments; and
- past environmental performance as measured against Government Environmental Conditions of approval.

### *1. INTRODUCTION*

The document should include an explanation of the following:

- identification of the project joint venturers (proponents) and responsible authorities;
- background and objectives of the proposal;
- brief details of the scope and timing of the proposal;
- relevant statutory requirements and approvals; and
- brief description of the environmental impact assessment process and the scope, purpose and structure of the document.

### *2. NEED FOR THE PROPOSAL*

The document should briefly describe the need for the proposal (expansion) so the public can understand why it is being proposed at this time. Broad costs and benefits of the proposal at local and regional levels could also be briefly discussed.

### *3. DESCRIPTION OF PROPOSAL*

It is important to include a description of the proposal itself, including specifically what is proposed, how it is to be carried out, the timing of the project, and what measures will be taken to ameliorate possible negative effects.

The processes involved in the operation of the proposed expansion of alumina production should be briefly explained. The physical elements of any new plant or changed activity should be described along with their functions. The inputs, outputs and by-products of each process should be explained. Materials handling procedures should be described and an indication of gross quantities given. Transport arrangements should also be described.

The following information should be included:

- factors affecting timing, direction, rate and extent of mining related activities near Boddington, including the quality and quantity of the bauxite resource;
- a table should be presented which summarises a mass balance of raw materials (inputs) and products and waste (outputs);
- a process flow chart of wastes generated; and
- type and location of major structures to be built at the refinery site (plant and tailings dams).

Whilst the proposal will be carried out at the existing location, many of the public may not have been involved in the original assessment. Consequently, this section should briefly outline the

location of existing and proposed operations. Appropriate maps of the area to be affected by the proposal (refinery site and mining area) should be included showing:

- location of the proposal;
- existing land uses and land status;
- environmentally sensitive areas;
- timing and areas to be cleared and subsequently rehabilitated for mining related activities (such as those within 10 year and longer term time frames); and
- areas for residue disposal.

## *4. DESCRIPTION OF THE EXISTING ENVIRONMENT*

The existing environment should be clearly described including physical, biological and human environment. Any updated information relating to flora and fauna, particularly any rare and endangered, restricted, priority or locally important species should be included.

## *5. POTENTIAL ENVIRONMENTAL IMPACTS AND MANAGEMENT*

Much of the potential environmental impacts and management of those impacts were described in the original proposal assessed in 1979. The past impacts and Worsley's performance in managing those impacts should be discussed, as a basis for assisting the EPA in determining the environmental acceptability of the proposed expansion.

The key environmental topics and environmental objectives are set out below under the three aspects of the proposal:

- bauxite mining and related activities;
- alumina refining and residue disposal; and
- social impacts.

### *Bauxite mining and related activities*

The EPA's objective is to ensure that the proponent mines bauxite in an environmentally acceptable manner and returns the mined areas to the State's management in a form which meets completion criteria approved by the State.

A guide for the proponent as to the key environmental topics involved in bauxite mining and related activities (including the conveyor), and how they should be considered in the CER together with commitments, are as follows:

| **Topic** | **Environmental Objectives** |
|---|---|
| Flora and fauna conservation | • To ensure that the biodiversity and sustainability of the eastern Darling Range forest ecosystems are maintained from adverse impacts of bauxite mining activities.<br>• To ensure that rare and endangered flora and fauna within the mining area are protected. |

| | |
|---|---|
| Mine rehabilitation | • To ensure that rehabilitation of mined areas in State Forest is timely, sustainable and meets completion criteria agreed by the State.<br>• To ensure that rehabilitation of mined areas on private property leaves the land in an environmentally stable and sustainable condition and meets the requirements of the private property owner. |
| Forest diseases | • To minimise the risk of bauxite mining activities introducing or spreading jarrah dieback or other forest diseases into areas of State and private forest. |
| Impact on other users of State forest | • To minimise the impacts of bauxite mining and related activities on other users of the State forest, by integrating as far as practicable Worsley's activities with CALM's forest management. |
| Water resources | • To ensure that environmental values of water resources, including water quality and quantity of potable resources, are maintained from adverse impacts of bauxite mining activities. |
| Noise | • To comply with statutory requirements so that the amenity of nearby residents is protected from noise impacts resulting from bauxite mining activities. |
| Dust | • To comply with statutory requirements so that the amenity of nearby residents is protected from dust impacts resulting from bauxite mining activities. |
| Public safety | • To restrict access by the general public to the mine operating areas in accordance with safety requirements. |
| Wastes | • To reduce as far as practicable the generation of solid and liquid wastes resulting from bauxite mining activities.<br>• To dispose of wastes in an environmentally acceptable manner. |

Related topics which should also be addressed include:

- impacts on forest flora and fauna (conservation and biodiversity), particularly in relation to endangered species that are listed by the State and Commonwealth Governments; at the end of mining no individual species of flora or fauna should be so depleted by mining to a level that would jeopardise its natural survival;
- relationship between long term mining plans and proposed conservation reserves;
- integration of bauxite mining with other land uses (eg timber harvesting, conservation, recreation, water catchments);
- minimisation of forest clearing, particularly in relation to haul road locations and other infrastructure;
- role of government agencies in the auditing of commitments and conditions, and in the review and approval of mining and rehabilitation plans;
- the sustainability of rehabilitation in the light of possible climatic changes resulting from global warming;
- maximum practicable return of fresh topsoil to pits;
- maximum practicable use (including environmental use) of residual forest materials;
- a process for reaching agreement with the State on completion criteria (criteria to be met before rehabilitated areas are handed back to the State's management);
- provisions for review of completion criteria by the EPA and the public;
- landscape impacts and management plans; and
- decommissioning of the crusher area, workshop, administration buildings and conveyor route.

### *Alumina refining and residue disposal*

The EPA's objective is to ensure that the proponent constructs and operates the alumina refinery and tailings dams in an environmentally acceptable manner such that the State inherits no financial liability or ongoing environmental management from environmental impacts associated with the proposal.

A guide for the proponent as to the key environmental topics involved in these activities, and how they should be considered in the CER together with commitments, are as follows:

| Topic | Environmental Objectives |
|---|---|
| Bauxite residue | • To design, construct and operate the residue areas in a manner that maintains the integrity of the containment system.<br>• To maximise, as far as practicable, the extraction of caustic soda from the bauxite residue.<br>• To minimise, as far as practicable, impacts on State Forest resulting from construction activities.<br>• To manage the residue areas in an environmentally acceptable manner until they meet the requirements of a closure and rehabilitation strategy agreed with the State. |
| Water resources | • To ensure that environmental values of water resources, including water quality and quantity of potable resources, are maintained from adverse impacts of refinery operations and bauxite residue disposal. |
| Noise | • To comply with statutory requirements so that the amenity of nearby residents is protected from noise impacts resulting from refinery operations. |
| Dust | • To comply with statutory requirements so that the ecological values outside of the refinery lease area and the amenity and health of nearby residents are protected from adverse dust impacts resulting from the refinery operations and bauxite residue disposal areas. |
| Gaseous emissions (NOX, SOx and odours) | • To comply with statutory requirements so that the ecological values of off-site areas and the amenity and health of nearby residents are protected from adverse gaseous emissions from the refinery operations. |

| | |
|---|---|
| Greenhouse gases | • To reduce as much as practicable the emission of greenhouse gases from project operations. |
| Decommissioning | • To decommission the refinery and associated infrastructure in an environmentally acceptable manner that the State inherits no financial liability or ongoing environmental management from environmental impacts associated with the proposal and is in accordance with statutory requirements. |
| Wastes (other than bauxite residue) | • To reduce as far as practicable the generation of solid and liquid wastes resulting from refinery operations.<br>• To dispose of wastes in an environmentally acceptable manner. |

The proponent should address the following aspects of the key environmental topics relating to the refinery and bauxite residue areas:

- impacts on the State Forest should be minimised. Factors such as minimising forest clearing and the utilisation of residue for construction (as opposed to new borrow pits) should be considered;
- the best practicable construction, operation, pollution-suppression (including low NOx emission equipment) and decommissioning (rehabilitation) technology should be used;
- the pre-refinery environmental values of surface and groundwater outside of the refinery lease area should not be jeopardised during or after the refinery operation. This relates to aquatic communities, adjoining vegetation, and water quality and quantity. Management of spills of caustic and other chemicals should be addressed;
- the closure strategy for the bauxite residue areas and refinery area should ensure that the State inherits no financial liability or ongoing environmental management from environmental impacts associated with the proposal;
- provisions for review of the closure strategy by the EPA and the public should be described;
- sustainability of rehabilitation in the light of possible climatic changes resulting from global warming;
- identification and management of risks and hazards;
- role of government agencies in the auditing of commitments and conditions; and
- greenhouse gases. The EPA's provisional policy on greenhouse gases requires the proponent to:

    1. Calculate greenhouse gas emissions associated with the proposal;
    2. estimate international offsets achieved by implementation of the proposal;

3. indicate "no regrets" measures adopted to reduce greenhouse gas emissions; and
4. consideration of a voluntary agreement with the State which includes annual estimation of greenhouse gases, commitments to implement "no regrets" measures and approaches to abate greenhouse gas emissions and enhance sinks.

*Social impact aspects of the project*

The EPA's objective is to ensure that the proponent undertakes the activities of the proposal with a minimum disruption to the local community during the construction, operational and decommissioning stages of the proposal.

A guide for the proponent as to the key environmental topics involved in social impact, and how they should be considered in the CER together with commitments, are as follows:

| **Topic** | **Environmental Objectives** |
|---|---|
| Impacts on local communities | • Ensure that the activities of the proposal are undertaken with minimum practicable disruption to the local community. |
| Community consultation | • Ensure that the local community is adequately consulted in relation to this proposal and any subsequent changes to the proposal. |
| Road and rail traffic | • To reduce as much as practicable the impacts of road and rail traffic resulting from the project on the affected communities. |
| Heritage areas | • To comply with statutory requirements for the protection of aboriginal and non-aboriginal heritage. |
| Buffer zones | • To maintain appropriate separation distances between project operations and sensitive areas in conjunction with relevant planning authorities. |

The following aspects should be considered in the CER together with commitments:

- impact of project workforce (construction and operational) and attendant population on local communities and nearest neighbours to sites during construction and operation;
- local employment opportunities and other local benefits;
- changes to the operation times and speed of the conveyor belt and how potential impacts on neighbours will be managed;

- impacts on local roads (eg Mornington Road) caused by additional traffic associated with the expansion; and

- potential impacts on local and regional planning for the area in general.

Other key issues may be raised during the preparation of the document, and ongoing consultation with the DEP and relevant agencies is recommended. Information used to reach conclusions should be properly referenced, including personal communications.

Assessments of the significance of an impact should be soundly based and lead to a discussion of the management issue.

In order to expedite the assessment, Worsley should discuss the format of each section with the assessment officer before submitting a draft document for informal review. Additionally, Worsley should supply the officer with an electronic form of the draft document and subsequently the final document upon its release for public review.

With respect to noise, there should be predictions of the levels of noise emissions from the various operating components of the proposal by competent acoustic persons. These levels should be compared with current background noise levels in all likely affected areas for all times of day and night. Predicted noise emissions should indicate the likely presence of special characteristics (eg tonal components) which may affect the level of annoyance generated by the noise. "Worst case" scenarios should be described, with the rate of occurrence of these conditions being indicated and compliance with existing and proposed noise regulations demonstrated. The discussion of noise emissions should make specific reference to the way in which seasonal wind patterns are likely to modify the impacts of those emissions.

## *6. MONITORING*

Whilst this issue has been dealt with in detail in the original proposal, real data for the monitoring of this operation are now available. The data should be used to describe the success (or otherwise) of the monitoring programs and indicate how problems (if any) were managed and how monitoring has been improved. This includes the monitoring of air, noise and water discharges to ensure that the plant is operating efficiently and the receiving environment is not being adversely impacted and specifically if it is able to absorb additional inputs without unacceptable impacts.

The specifications of all monitoring programs should be given and responsibility for the operation of that system should be assigned. Emphasis should be placed on how monitoring and plant operations will be adapted in light of monitoring or auditing results.

Procedures should be outlined for reporting the results of the monitoring of environmental impacts to the appropriate authorities.

## *7. CONCLUSION*

Conclusions of the overall environmental impact of the proposal, including proposed ameliorative measures should be stated together with an assessment of the environmental acceptability of the project.

## *8. PUBLIC CONSULTATION*

A description should be provided of the public participation and consultation activities undertaken by Worsley in preparing the CER. This should outline the activities, the groups or individuals involved and the objectives of the activities.

A summary of concerns raised should be documented along with how each concern has been addressed. Cross reference should be made with the description of environmental management

for the proposal which should clearly indicate how community concerns have been addressed. Where these concerns are dealt with via other departments or procedures outside the Environmental Protection process, these can be noted and referenced in this section.

## *9. ENVIRONMENT MANAGEMENT COMMITMENTS*

It is very useful to give, wherever appropriate, specific commitments regarding all components and procedures of the environmental management program (see note on commitments below). This could include topics not previously addressed in the original assessment or for topics which have changed from the original assessment. If any commitment made in the original assessment needs to be deleted because it is no longer relevant or upgraded because of changed circumstances, this is the opportunity to propose such a change.

All specific commitments to protect the environment should be separately listed, numbered and take the form of:

- who will do the work;
- what is the work;
- when and where the work will be carried out,;
- what regulatory agencies will be involved; and
- whose satisfaction will the work be carried out to.

The method of implementation of the proposal and all commitments made by the proponent in the document would become legally enforceable under the environmental conditions of the Minister for the Environment's approval. Accordingly, key commitments will show that Worsley is committed to actionable and auditable management of the key environmental topics. The proponent should consult the DEP on the wording of the commitments because they need to be enforceable to have any value.

## *10. HOW TO MAKE A PUBLIC SUBMISSION*

The document should include instructions to members of the public as to how they can make a submission to the Environmental Protection Authority. It is a standard item of information in all public review documents. The EPA can supply a free pamphlet entitled "How to Make a Submission". This pamphlet should be circulated with each document

## *ADDITIONAL INFORMATION*

REFERENCES
All references should be listed.

GUIDELINES
A copy of these guidelines should be included in the document.

GLOSSARY
A glossary should be provided in which all technical terms, and unfamiliar abbreviations and units of measurement are explained in simple language.

APPENDICES
Where detailed technical or supporting documentation is required, this should be placed in appendices.

# WESTERN AUSTRALIA
# DEPARTMENT OF ENVIRONMENTAL PROTECTION

## Air Quality and Air Pollution Modelling Guidelines

1 The proponent is responsible for identifying and quantifying all emissions to atmosphere with a potential to have non-trivial impact on the environment (including impact on human health, nuisance, amenity, vegetation - natural and agricultural, fauna - natural and agricultural). Emissions of potential concern include $SO_2$, $NO_X$, volatile organic compounds, fluorides, hydrogen sulphide, particulates, odorous gases, heavy metals and other toxic compounds, unless these are trivial (to be justified). Additionally, the formation and impact of secondary pollutants such as photochemical smog should be assessed if applicable.

2 For all primary and secondary pollutants which cannot be dismissed as being trivial, the proponent must provide predictions of the impact of various emissions on the various elements of the environment, in the form of concentrations or rates of deposition over the range of time scales (averaging periods) normally considered for each pollutant, and assess the magnitude of this impact against guidelines/goals/standards determined from local and international literature and/or field investigations of environmental sensitivity. Data from experiments or justifiable extrapolations from published literature will also be required on the susceptibility of natural vegetation and crops. In the case of each such pollutant, the assessment must account for existing concentrations caused by other sources and therefore estimate the cumulative concentration. *The assessment must consider not only emissions which are continuous in nature but also emissions which are intermittent, such as those associated with plant start-up/shut-down and plant upset conditions. Intermittent emissions which are insignificant in magnitude and/or very improbable in the lifetime of the plant may be screened out; the remaining emissions should be modelled together on a probabilistic basis to estimate the total plant impact.* The proponent is invited to carry out "worst case" analyses (eg simplified conservative pollution modelling techniques) in order to prove to the DEP that comprehensive modelling procedures for particular pollutants are not warranted. The models and/or worst case calculation procedures must be adequately described, with reference to their source.

3 For pollutants requiring comprehensive modelling the proponent will need to obtain at least one (preferably two) year's data on the meteorology of the area, with high data recovery and verifiable data accuracy, plus data from field experiments as prove to be necessary, in order to obtain the following data set of 10-minute averages (longer averaging periods require justification):

- wind speed;
- wind direction;
- direction standard deviation;
- air temperature;
- relative humidity or a related parameter;
- surface layer sensible heat flux, moisture flux and friction velocity determined via methods acceptable to the DEP;
- mixing height (considering morning temperature inversions, nocturnal boundary layers, thermal internal boundary layers in onshore flow, and sea breezes), estimated or measured via methods acceptable to the DEP;
- strength of capping inversions above mixed layers, estimated by methods acceptable to the DEP; and

- atmospheric stability (a derivative of parameters mentioned above) estimated by a method acceptable to the DEP.

Apart from providing a data base for conventional dispersion modelling, the data mentioned above will be essential for analysis/modelling of the following important phenomena:

(a) trapping of plumes in mixed layers of limited height or, alternatively penetration of plumes through elevated temperature inversions;
(b) vertical plume dispersion in convective conditions; and
(c) fumigation of plumes into encroaching mixed layers (onshore and offshore winds). Investigations of this phenomenon will require estimates of wind direction shear in stable layers.

The proponent is invited to demonstrate to the DEP that complicated or costly monitoring programs and/or modelling procedures for particular meteorological parameters are not warranted.

NOTES:

(i) The data set described above would be the minimum necessary for comprehensive modelling; the proponent is responsible for assessing the full range of pollution dispersion issues and designing an appropriate monitoring program.

(ii) Where items of data are not based on the results of continuous monitoring (eg. based instead on intermittent field experiments or unverified hypotheses), the uncertainty of estimates must be offset by conservatism in these estimates.

*(iii) In the experience of the DEP, intermittent emissions (plant upsets etc) result in far more pollution complaints than normal emissions from operating industries. Hence it is important to properly assess intermittent emissions. The analyses employed for hazard and risk assessment may be applied to estimate the magnitude and probability of the relevant range of emissions. Screening of emissions cases must be based on the joint consideration of probability and magnitude of emission. The DEP is able to provide guidance on how to screen and model intermittent emissions.*

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## QUALITY ASSURANCE

For QA purposes these draft guidelines were circulated as early as possible to all parties who have requested an input or who will give expert advice to the EPA on the proposal.

The draft guidelines were circulated between 31/10/95 and 2/11/95 with responses due back by 24/11/95. Copies were sent to the following parties:

Pollution Control Division, DEP - Pollution issues

Policy and Investigations Division DEP

DEP Bunbury regional office

WAWA - Water supply and pollution control issues:

DRD

DOME (Collie)

CALM (Head office)

Western Power

Shire of Harvey

Shire of Collie

Shire of Boddington

South West Development Commissioning

Port of Bunbury

Westrail

Main Roads Bunbury

City of Bunbury

EPA - draft guidelines distributed 1/11/95; revised version 071295 distributed to Chairman 8/12/95 and to EPA members 11/12/95; discussed and approved with minor amendments at EAC 14/12/95; final version 141295 to Deputy Chairman 15/12/95 for sign off.

# APPENDIX 2

# DEFINITIONS OF RARE AND PRIORITY FLORA

## DEFINITIONS OF RARE AND PRIORITY FLORA[1]

### Declared Rare Flora - Extant Taxa

Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

### Declared Rare Flora - Presumed Extinct

Taxa which have not been collected, or otherwise verified, over the past 50 years despite extensive searching, or of which all known populations have been destroyed more recently, and have been gazetted as such.

### Priority One - Poorly Known Taxa

Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, eg. road verges, urban areas, farmland etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as "rare flora", but are in urgent need of further survey beforehand.

### Priority Two - Poorly Known Taxa

Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (ie not currently endangered). Such taxa are under consideration for declaration as "rare flora", but not in need of urgent survey beforehand.

### Priority Three - Poorly Known Taxa

Taxa which are known from several populations, at least some of which are not believed to be under immediate threat (is not currently endangered). Such taxa are under consideration for declaration as "rare flora", but not in need of urgent survey beforehand.

### Priority Three - Rare Taxa

Taxa which are considered to have been adequately surveyed and whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

### Priority Four - Rare Taxa

Taxa which are considered to have been adequately surveyed and whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

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[1]*Source*: CALM, 1995

# APPENDIX 3

# LOCAL AND REGIONAL DISTRIBUTION OF PRIORITY FLORA SPECIES RECORDED IN THE SADDLEBACK AREA

Mattiske Consulting

# LOCAL AND REGIONAL DISTRIBUTION OF PRIORITY FLORA SPECIES RECORDED IN THE SADDLEBACK AREA

**Mattiske Consulting**

A total of 56 families, 179 genera, 374 native species, 21 introduced and 403 taxa (including subspecies and varieties) have been recorded on the Boddington Mining Lease Areas (Worsley Alumina, 1985 and Mattiske Consulting, 1995b).

No plant species which are listed in the Wildlife Conservation (Rare Flora) Notice (July 4) 1995, gazetted pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act 1950*, were located in the Boddington Lease Areas. Similarly, no plant species listed under the federal *Endangered Species Protection Act, 1992* were located in the Boddington Lease Area.

A total of 15 Priority Flora species listed by CALM (1995) were located in the Boddington Bauxite Lease Areas, (see attached table).

The species which occur in the plant communities - 19JLc, 19JBg and 19JSd, namely - *Calytrix simplex ssp. simplex, Dryandra subinnatifida, Lasiopetalum cardiophyllum, Senecio leucoglossus, Templetonia drummondii* and *Tetratheca pilifera* may in some areas be directly affected by the proposed extensions to the mining operations. All but one of these priority flora species occur in the range of heath communities (22HHu, 23HDc and 24HCq). The other species - *Tetratheca pilifera*, is distributed widely through the plant communities on the Boddington Mining Lease Areas, including 19JH1, 19JMr, 19JPs, 19JLc, 19JSd, 11W1 and 11W2. The site vegetation types 22HHu, 23HDc, 24HCq, 19H1, 11W1 and 11W2 are not likely to be significantly impacted by the proposed extensions to the mining operations, therefore potentially providing some protection for all of these Priority Flora species.

In reviewing the priority species listed below, the following species are geographically restricted either to the Boddington region or to the eastern Jarrah forest areas:

- *Lasiopetalum cardiophyllum*
  This species is restricted geographically to the Mt Saddleback, Bannister and Wandering areas. In the Mt Saddleback area it occurs primarily in the 19JLc *Eucalyptus marginata - Allocasuarina fraseriana* forest; although it does occur in 19 JMr, 19 JPs, 19 JBg, 11W1 and 23 HDc. In addition this species has been recorded on rehabilitation areas.

- *Stenanthemum intropubens (ms)*
  This species belongs to a genera which has recently been revised. Currently this taxon is known from one collection held in Western Australian Herbarium from the Mt Saddleback area (Worsley Alumina 1985) within the one plant community 22HHu on the upper slopes. Further studies are required on this Priority 1 species to assess its conservation status.

- *Stenanthemum nanum*

This species is geographically restricted to the Boddington and Brookton Highway area and therefore although not under any immediate threat, it does require further investigation to clarify its conservation status in the eastern forest areas.

Of the 15 Priority Flora species located in the Boddington Lease Areas, *Dryandra subpinnatifida* and *Eucalyptus aspersa* have been included in the seed mixture for rehabilitation areas and have been recorded in these areas (1986 to 1995). In addition the other Priority Flora species - *Acacia gemina (ms), Lasiopetalum cardiophyllum, Senecio leucoglossus, Stenanthemum coronatum* and *Templetonia drummondii* have been recorded in these areas, although these species have not been included in the seed mixture for the rehabilitation areas (1986 to 1995). Although *Stenanthemum coronatum* was recorded on the rehabilitation areas, it has not been located in any undisturbed areas on the Boddington area to date. This species is relatively widespread and ranges in location from Clackline to Dryandra, Wooroloo and Darkan. The absence of this species in the baseline data relates to the sampling regime rather than its rarity in view of its wider distribution.

| Species | Located in mapping Units on Boddington Bauxite Mine Areas | Priority Rank | Known Geographical Distribution | Presence (+) in Rehabilitation Areas and Ranking Abundance |
|---|---|---|---|---|
| Acacia gemina (ms) | 19jsd, 23HDc | 2 | Narrogin, Boyagin Rock Reserve, Mt Saddleback, Hyden | +(ns) 2 |
| Asteridia gracilis | 23HDc | 1 | Gosnells, Mt Saddleback | N/A |
| Calytrix simplex ssp. simplex | 19JLc, 23HDc | 1 | Armadale, Mt Saddleback | N/A |
| Cryptandra polyclada ssp. polyclada | 23HDc | 3 | Tammin, Lake King, Boorabin, Lake Varley, Boddington | N/A |
| Dryandra subpinnatifida | 19JBg, 23HDc | 3 | Boddington, Birdwhistle, Dryandrae, Kojonup, Broomhill | + (s) 2 |
| Eucalyptus aspersa | 24HCq | 4 | Mt Cooke, North Bannister, Mt Saddleback, Mayanup, Farrar, Wandering, Nalyerin | + (s) 2 |
| Lasiopetalum cardiophyllum | 19JLc, 19JPs, 19JBg, 19JMr, 11WI, 23HDc, 24HCq | 2 | Mt Saddleback, Bannister, Wandering | + (ns) 3 |
| Senecio leucoglossus | 19JHi, 19JMr, 19JPs, 19JLc, 19JBg, 19JSd, 24HCq | 4 | Mundaring, Harvey, Mt Saddleback, Dwellingup, Darling Ranges | + (ns) 3 |
| Spyridium oligocephalum | 23HDc | 3 | Pingrup, Jerramungup, Kalgan River, Fitzgerald NP | N/A |
| Stenanthemum coronatum | | 3 | Clackline, Dryandra, Wooroloo, Darkan | + (ns) 1 |
| Stenanthemum intropubens (ms) | 22HHu | 1 | Boddington | N/A |
| Stenanthemum nanum | 23HDc | 1 | Boddington, Brookton Highway | N/A |
| Templetonia drummondii | 19JPs, 19JLc, 19JBg, 11W1, 11W2, 23HDc | 4 | Boddington, Williams, Midland, Glen Forest | + (ns) 1 |

| | | | | |
|---|---|---|---|---|
| Tetratheca pilifera | 19JH1, 19JMr, 19JPs, 19JLc, 19JSd, 11W1, 11W2 | 3 | Two Rocks, Chidlow | N/A |
| Verticordia huegelii va. decumbens | 23HDc | 3 | Darling Range, Boulder Rock, Mogumber | N/A |

(ns - not seeded in rehabilitation areas; s- seeded in rehabilitation areas)

Abundance Ranking Scale:

1. Rare recordings in low numbers in rehabilitation areas.
2. Occasional recordings in low numbers in rehabilitation areas.
3. Regular recordings in in low numbers rehabilitated areas.

# APPENDIX 4

# LIST OF VERTEBRATES RECORDED IN FORESTED AND REHABILITATED AREAS OF THE SADDLEBACK AREA SINCE 1982

Ninox Wildlife Consulting

## LIST OF VERTEBRATES RECORDED IN FORESTED AND REHABILITATED AREAS OF THE SADDLEBACK AREA SINCE 1982

**Ninox Wildlife Consulting**

| | | NATIVE VEGETATION | REHABILITATION AREAS |
|---|---|---|---|
| **BIRD SPECIES** | | | |
| **DROMAIIDAE** | | | |
| Dromaius novaehollandiae | Emu | X | X |
| **ACCIPITRIDE** | | | |
| Lophoictinia isura | Square-tailed Kite | X | X |
| Accipiter fasciatus | Brown Goshawk | X | |
| A. cirrhocephalus | Collared Sparrowhawk | X | |
| Aquila audax | Wedge-tailed Eagle | X | |
| Hieraetus morphnoides | Little Eagle | X | |
| **FALCONIDAE** | | | |
| Falco peregrinus | Peregrine Falcon | X | |
| F. longipennis | Australian Hobby | X | |
| F. berigora | Brown Falcon | X | |
| F. cenchroides | Australian Kestral | X | X |
| **TURNICIDAE** | | | |
| Turnix varia | Painted Button-quail | X | X |
| **COLUMBIDAE** | | | |
| Phaps chalcoptera | Common Bronzewing | X | X |
| **CACATUIDAE** | | | |
| Calyptorhynchus magnificus | Red-tailed Black Cockatoo | X | |
| C. baudinii | White-tailed Black Cockatoo | X | |
| C. f. latirostris | White-tailed Balck Cockatoo | X | X |
| **LORIIDAE** | | | |
| Glossopsitta porphyrocephala | Purple-crowned Lorikeet | X | |
| **PLATYCERCIDAE** | | | |
| Purpureicephalus spurius | Red-capped Parrot | X | X |
| Platycercus icterotis | Western Rosella | X | X |
| Barnardius zonarius | Port Lincoln Ringneck | X | X |
| Neophema elegans | Elegant Parrot | X | |
| **CUCULIDAE** | | | |
| Cuculus pallidus | Pallid Cuckoo[2] | X | |

| | | | |
|---|---|---|---|
| C. pyrrhophanus | Fan-tailed Cuckoo | X | |
| Chrysococcyx basalis | Horsfield's Bronze - Cockatoo | X | |
| C. lucidus | Shining Bronze-Cockatoo | X | X |
| **STRIGIDAE** | | | |
| Ninox novaeseelandiae | Southern Boobook | X | |
| **PODARGIDAE** | | | |
| Podargus strigoides | Tawny Frogmouth | X | |
| **AEGOTHELIDAE** | | | |
| Aegotheles cristatus | Australian Owlet-nightjar | X | |
| **ALCEDINIDAE** | | | |
| Halcyon sancta | Sacred Kingfisher | X | |
| **MEROPIDAE** | | | |
| Merops ornatus | Rainbow Bee-eater | X | X |
| **HIRUNDINIDAE** | | | |
| Cecropis nigricans | Tree Martin | X | |
| **MOTACILLIDAE** | | | |
| Anthus novaeseelandiae | Richard's Pipit | X | X |
| **CAMPEPHAGIDAE** | | | |
| Coracina novaehollandiae | Black-faced Cuckoo-shrike | X | X |
| Lalage sueuril | White-winged Triller | X | X |
| **MUSCICAPADAE** | | | |
| Petrocia multicolor | Scarlet Robin | X | X |
| P. goodenovii | Red-capped Robin | X | X |
| Eopsaltria georgiana | White breasted Robin | | X |
| E. griseogularis | Western Yellow Robin | X | X |
| Pachycephala pectoralls | Golden Whistler | X | X |
| P. rufiventris | Rufous Whistler | X | X |
| Colluricincla harmonica | Grey Shrike Thrush | X | X |
| Myiagra inquieta | Restless Flycatcher | X | |
| Rhipidura fuliginosa | Gey Fantail | X | X |
| R. leucophrys | Willie Wagtail | X | |
| **MALURIDAE** | | | |
| Malurus splendens | Splendid Fairy-wren | X | X |
| **ACANTHIZIDAE** | | | |
| Sericomis frontalis | White-browed Scrubwren | X | X |
| Smicrornis brevirostris | Weebill | X | X |
| Gerygone fusca | Western Greygone | X | X |
| Acanthiza apicalis | Inland Thornbill | X | X |
| A. inornata | Western Thornbill | X | X |
| A. chrysorrhoa | Yellow-rumped Thornbill | X | |
| **NEOSITTIDAE** | | | |

| | | | |
|---|---|---|---|
| Daphoenositta spachrysoptera | Varied Sittella | X | X |
| **CLIMACTERIDAE** | | | |
| Climacteris rufa | Rufous Treecreeper | X | |
| **MELIPHAGIDAE** | | | |
| Anthorchaera carunculata | Red Wattlebird | X | |
| A. chrysoptera | Little Wattlebird | X | X |
| Lichenostomus virescens | Singing Honeyeater | X | |
| L. leucotis | White eared Honeyeater | | X |
| L. ornatus | Yellow-plumed Honeyeater | | X |
| Melithreptus brevirostris | Brown-headed Honeyeater | X | X |
| M. lunatus | White-naped Honeyeater | X | X |
| Lichmera indistincta | Brown Honeyeater | X | X |
| Phylidonyris novaehollandiae | New Holland Honeyeater | X | X |
| P. nigra | White-cheeked Honeyeater | X | X |
| P. melanops | Tawny-crowned Honeyeater | X | X |
| Acanthorhynchus supercillosus | Western Spinebill | X | X |
| **DICAEIDAE** | | | |
| Dicaeum hirundinaceum | Mistletoebird | X | |
| **PARDALOTIDAE** | | | |
| Pardalotus punctatus | Spotted Pardalote | X | X |
| P. striatus | Striated Pardalote | X | X |
| **ZOSTEROPIDAE** | | | |
| Zosterops lateralls | Silvereye | X | X |
| **GRALLINIDAE** | | | |
| Grallina cyanoleuca | Australian Magpie-lark | X | |
| **ARTAMIDAE** | | | |
| Artmaus cyanopterus | Dusky Woodswallow | X | |
| **CRACTICIDAE** | | | |
| Gymnorhina tibicen | Australian Magpie | X | X |
| Strepera versicolor | Grey Currowong | X | X |
| **CORVIDAE** | | | |
| Corvus coronoides | Austraian Raven | X | X |

| MAMMAL SPECIES | | | |
|---|---|---|---|
| **TACHY GLOSSIDAE** | | | |
| Tachyglossus aculeatus | Short-beaked Echidna | X | X |
| **DASYURIDAE** | | | |
| Dasyurus geoffroii | Chuditch | X | |
| Phascogale tapoatafa | Brush-tailed Phascogale | X | |
| Antechinus falvipes | Yellow-footed Antechinus | X | |
| Sminth opsis gilberti | Common Dunnart | X | X |
| S. griseoventer | Common Dunnart | X | |
| **PHALANGERIDAE** | | | |
| Trichosurus vulpecula | Common Brushtail Possum | X | X |
| **BURRAMYIDAE** | | | |
| Cercartetus concinnus | Western Pygmy Possum | X | X |
| **TARSIPEDIDAE** | | | |
| Tarsipes rostratus | Honey-possum | X | |
| **MACROPODIDAE** | | | |
| Macropus irma | Western Brush Wallaby | X | X |
| M. fuliginosus | Western Grey kangaroo | X | X |
| **MOLOSSIDAE** | | | |
| Tadarida australis | White-striped Mastiff-bat | X | |
| Mormopterus planiceps | Little Mastiff-bat | X | |
| **VESPERTILIONIDAE** | | | |
| Nycotophilus major | Greater Long-eared Bat | X | |
| N. gouldi | Gould's Long-eared bat | X | |
| N. geoffroyl | Lesser Long-eared Bat | X | |
| Chanlinolobus gouldii | Gould's Wattled Bat | X | |
| C. morio | Chocolate Wattled Bat | X | |
| Eptesicus regulus | King River Eptesicus | X | |
| | | | |
| **AMPHIBIAN AND REPTILE SPECIES** | | | |
| **AMPHIBIANS** | **Terrestrial Frogs** | | |
| Crinia geogiana | | X | |
| C. pseudinsignifera | | X | X |
| Heleioporus barycragus | | X | |
| H. eyrei | | X | |
| H. inomatus | | X | |
| Limnodynastses dorsalis | | X | X |

| | | | |
|---|---|---|---|
| Pseudophryna guentheri | | X | X |
| **HYLIDAE** | **Tree Frogs** | | |
| Litoria adelaidensis | | X | |
| L. moorei | | X | |
| **GEKKONIDAE** | **Geckos** | | |
| Crenadactylus ocellatus | | X | |
| Diplodactylus polyophtalmus | | X | X |
| Oedura reticulata | | X | |
| Phyllodactylus marmoratus | | X | X |
| Underwoodisaurus millii | | X | X |
| **PYGOPODIDAE** | **Legless Lizards** | | |
| Aprasia pulchella | | X | |
| Delma fraseri | | X | X |
| Lialis burtonis | | X | X |
| **AGAMIDAE** | **Dragon Lizards** | | |
| Pogona m. minor | | X | X |
| **SCINCIDAE** | **Skinks** | | |
| Bassiana trilineata | | X | X |
| Crytoblepharus plagiocephalus | | X | X |
| Ctenotus labillardieri | | X | |
| Egernia napoleonis | | X | |
| Hemiergis I. initialis | | X | X |
| Lerista distinguenda | | X | |
| Menetia greyii | | X | X |
| Morethia obscura | | X | X |
| Tiliqua r. rugosa | | X | X |
| **VARANDAE** | **Monitors** | | |
| Varanus gouldii | | X | |
| **TYPHLOPIDAE** | **Blind Snakes** | | |
| Ramphotyphlops australis | | X | |
| **BOIDAE** | **Pythons** | | |
| Morelia spilota imbricata | | X | |
| **ELAPIDAE** | **Elapid Snakes** | | |
| Neelaps bimaculatus | | X | |
| Pseudonaja affinis affinis | | X | |
| Rhinoplocephalus gouldii | | X | X |
| R. nigriceps | | X | |

| INTRODUCED SPECIES | | | |
|---|---|---|---|
| **ALCEDINIDAE** | | | |
| Dacelo novaeguineae | Laughing Kookaburra | X | X |
| **MURIDAE** | | | |
| Rattus rattus | Black Rat | X | X |
| Mus musculus | House Mouse | X | X |
| **LEPORIDAE** | | | |
| Oryctolagus cuniculus | Rabbit | X | X |
| **CANIDAE** | | | |
| Vulpes vulpes | Fox | X | X |
| **FELIDAE** | | | |
| Felis catus | Feral Cat | X | X |
| **SUIDAE** | | | |
| Sus scrofa | Feral Pig | X | |
| **BOVIDAE** | | | |
| Ovis aries | Sheep | X | |

# APPENDIX 5

# BODDINGTON BAUXITE MINE
# FOREST HYGIENE MANAGEMENT

# BODDINGTON BAUXITE MINE
# FOREST HYGIENE MANAGEMENT

## PREAMBLE

Worsley is committed to a forest hygiene management programme which is regularly reviewed and modified. The objectives of this current program are to:

- prevent the introduction of jarrah dieback and other forest diseases into project operation areas;
- limit the spread of jarrah dieback and other forest diseases from infected areas and prevent the spread of disease into disease-free areas;
- prevent the introduction of exotic grasses and weeds to project operation area; and
- educate our people as to their responsibilties for forest hygiene management.

Four (4) principles, fundmental to forest hygiene management at the bauxite mine are:

1. Vehicles and equipment must be clean before they are utilised on the minesite.
2. Vehicle and equipment movement within the Unrestricted Area and along Safe Roads, is not subjected to washdown conditions regardless of soil moisture conditions.
3. Under dry soil moisture conditions, washdown conditions are not required when leaving a safe and unsafe road assuming that wet areas or streams have not been crossed over.
4. Under wet and dry soil conditions, vehicles and equipment moving from a restricted Area must be cleaned down.

## TERMINOLOGY

The bauxite mine project area is classified into Dieback Free Areas, Restricted Areas, Safe Roads and Unsafe Roads, and Unrestricted Areas.

### 1. DIEBACK FREE AREAS

Native forest and mine-pit rehabilitation where the symptoms of dieback have not been observed.

### 2. RESTRICTED AREAS

Native forest, mine-pit rehabilitation and agricultural land where either;

1. dieback or armillaria has been identified. or
2. there is an absence of dieback indicator species, or
3. there is a high potential risk for dieback.

## 3. SAFE ROADS

Any sealed or gravel road that is well-drained. This is an unfavourable environment for dieback survival and hygiene risk is low. Included in this category are haul roads, Tunnel Road, Forty-Hollow Road and other roads specifically nominated by the Environmental Officer.

## 4. UNSAFE ROADS

Tracks and access was which are poorly drained and regularly 'pond' during rainfall events. These are favourable environments for dieback survival and the spread of dieback by vehicles. Hygiene risk is medium to high. Unsafe roads are signed posted within the mining operations area. Where use is to be made of an unsignposted road under wet soil conditions, assume it is unsafe or obtain a clearance from the Emergency Services Officer based at the Gatehouse.

## 5. UNRESTRICTED AREAS

- Areas originally classified as Dieback Free which have been cleared or designated for mining operations and are encompassed with perimeter drainage.

- Areas originally classified as restricted and have been cleared, topsoil removed and are encompassed with perimeter drainage.

## SOIL MOISTURE

Two categories of soil moisture conditions are use at the bauxite mine:
**DRY SOIL** and **WET SOIL**. these are broadly defined by seasonal considerations;

DRY: November - April - low hygiene risk;
WET: May - October - high hygiene risk, but acutal conditions must be assessed at the time.

Summer rain (more that 5 mm in a single rainfall event) can cause the soil moisture to be reclassified from DRY to WET wheras soil moisture can be reclassified from WET to DRY during a period of dry weather in the winter months. Soil moisture is classified by the Environmetnal Officer and signposted adjacent to the gatehouse.

## EDUCATION

The objective is to ensure that employees develop and maintain a sound working knowledge of the bauxite mine forest hygiene maangement programme.

New employees are inducted in the forest hygiene management program as part of the company's formal induction process. Training in forest hygiene management is incorporated into the introductory Environmental Induction and delivered as follows:

- presentation of the Environmental Section of the BBM employee induction programme;
- presentation and discussion of the bauxite forest hygiene handbook;
- view and discuss video on Environmental Matters; and
- minesite tour.

The following programs are designed to keep employees informed and aware of their environmental responsibilites relating to forest hygiene management:

  - one-day envviromental inductions for new employyee and re-induction for employees after five years of service with the company;
  - forest hygiene workshop programmes (annually);
  - workforce interaction meetings (six monthly).

- **Contractors** working on the minesite are required to be inducted and have a sound working knowledge of the bauxite mine forest hygiene management procedures at the gatehouse prior to commencing any activity.

## SITE ENTRY

- **Access** to the minesite for vehicles and equipment requiring or possibly requiring washdown is via the gatehouse. Access via the back gate is only permitted for vehicles that are clean and have been issued with an Overland Conveyor Quarantine permit.
- **Drivers** of all vehicles entering the minesite are to be reminded (by appropriate signposting) of the need for vehicles to not carry in mud or plant material (eg in wheel arches or tyre treads) that roiginates directly from forested or agricultural land outside the mining areas.
- **The driver** of any vehicle arriving at the gatehouse in an apparantly 'unclean' condition will be requested by the duty Emergency Services Officer to confirm that they are not a hygiene hazard. Vehicles considered to be a hygiene hazard will require washdown before access is authorised.
- **Contractors** and hire equipment is required by standard contract/hire conditions to present to site hygienically clean.

- **Contract Co-ordinators** are to arrange inspection of equipment prior to entry to site. Access will not be authorised for equipment carrying mud or plant material. Wash down facilities are only to be made available to contractors or for hire equipment under exceptional circumstances of where prior arrangements have been made through contract documentation.

## WASHDOWN PROCEDURES

- Vehicles or equipment requiring washdown for access to the minesite are to be cleaned at the Anpress unit. Washdown solutions (sodium hypochlorite) at a concentration of 0.5 litres of 12.5% free chlorine solution per 1 000 litres of water are required for satisfactory hygiene control.

- The washdown facility is to be "hosed down" after use and kept clean of mud at all times.

- Where operations require the use of mobile washdown units (see section WHEN TO CLEAN DOWN) for hygiene control, washdown units must be in place and fully functional before activity proceeds.

## VEHICLE MOVEMENT RESTRICTIONS

The spread of dieback disease has been greatly facilitated by human activity. Any strategy that limits or excludes the unnecessary presence of human activites in the forested area will minmise the hygiene risk. Minesite personnel are required to restrict vehicular movement to roads that are classified as "safe" (ie sealed or well-drained roads) and avoid entering forested or agricultural areas unnecessarily.

## TIMING AND PLANNING OF OPERATIONS

Ideal climatic conditions conducive to growth and dispersal of the dieback disease occur during the warm, moist periods encountered between April and November and under thunderstorm or cyclonic events during the summer months.

Operations that require soil or vegetation disturbance, including drilling, surveying, timber harvesting, vegetation clearing and wherever possible, topsoil recovery should be carried-out during the driest months of the year. For operations carried out during the wet months, Operation Co-ordinators and Contract Co-ordinators are required to liaise with the Environmental Officer to develop a management strategy with a minimal forest hygiene risk.

## WHEN TO CLEAN DOWN

| | SOIL CONDITIONS | |
|---|---|---|
| **MOVING FROM:** | **WET** | **DRY** |
| Safe Road - Dieback Free Area/Restricted Area/Unsafe Road/Unrestricted Area | No | No |
| Unsafe Road - Dieback Free Area/Restricted Area/Safe Road/Unrestricted Area | Yes | Yes/No * |
| Dieback Free Area - Restricted Area/Safe Road/Unsafe Road/Unrestricted Area | Yes | No |
| Restricted Area - Dieback Area/Safe Road/Unsafe Road/Unrestricted Area | Yes | Yes |
| Unrestricted Area - Dieback Free Area/Safe Road/Unsafe Road/Restricted Area | No | No |

* Light vehicles which have not crossed wet areas or stream do not need to wash-down, but all earth-moving equipment and light vehicles which have been through wet areas must be cleaned-down.

## SAFE ROAD/UNSAFE ROAD INTERSECTIONS

The intersections of safe roads and unsafe roads (eg Fletcher Road/Haulroad crossing) are required to be dosed with copper sulphate (30g per 1 000 litres of water) during wet soil conditions on a weekly basis during mining operations.

## FOREST HYGIENE STATUS OF OPERATIONS AREA

A forest hygiene classification map of the Operations Area will be displayed at the gatehouse and the Production and Maintenace notice boards and made available on request to employees, contractors and visitors through the Enviromental Officer.

Forest hygiene surveys of the Operations Areas will be undertaken as required to ensure the map is up to date, covers all mining and drilling operation areas and its utility maximised for mangement purposes.

Soil moisture conditions will be assessed on a daily basis and signposted near the Gatehouse on the mine access road.

# APPENDIX 6

# MINING NOISE EVALUATION

# MINING NOISE EVALUATION

The following imformation is contained in this Appendix.

1. Predicted L10 sound power levels at nearest residences for various wind speeds and directions under three mining operation scenarios.

2. Measured sound power levels from mining equipment.

3. Wind roses showing the seasonal wind speed and direction for three time periods - 7.00am - 7.00pm, 7.00pm - 10.00pm and 10.00pm - 7.00am.

# BODDINGTON BAUXITE MINE EQUIPMENT SOUND POWER LEVELS (0m FROM SOURCE)
## DATA VALID FROM NOV 1995

| SOURCES USED IN ENM MODELLING | OPERATING CONDITIONS TESTED | OCTAVE BAND NOISE POWER IN dB(lin) | | | | | | | | | | TOTAL NOISE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 22.5 TO 45 Hz | 45 TO 90 Hz | 90 TO 180 Hz | 180 TO 355 Hz | 355 TO 710 Hz | 710 TO 1400 Hz | 1400 TO 2800 Hz | 2800 TO 5600 Hz | 5600 TO 11200 Hz | 11200 TO 22400 Hz | LIN | AWT |
| PRIMARY CRUSHER | FULL OPERATING CONDITIONS | 117 | 118 | 118 | 120 | 116 | 110 | 106 | 101 | 93 | 84 | 125 | 117 |
| SECONDARY CRUSHER | TWO TRAINS ONLY (B & C) | 117 | 116 | 117 | 117 | 116 | 107 | 108 | 103 | 99 | 94 | 124 | 117 |
| BACKHOE | FULL OPERATING CONDITIONS | 105 | 116 | 122 | 122 | 111 | 110 | 107 | 103 | 99 | 91 | 126 | 117 |
| FRONT END LOADER | DIGGING IN HARD CONDITIONS | 100 | 110 | 120 | 116 | 110 | 110 | 109 | 103 | 101 | 97 | 123 | 116 |
| FRONT END LOADER | 2000 RPM ( ASSUMES EASIER DIGGING ) | 98 | 108 | 111 | 111 | 108 | 106 | 103 | 99 | 94 | 88 | 117 | 111 |
| REAR DUMP TRUCK | TIPPING LOAD AT PRIMARY CRUSHER | 106 | 117 | 127 | 115 | 111 | 107 | 108 | 105 | 97 | 93 | 128 | 116 |
| REAR DUMP TRUCK | 2000 RPM ( ASSUMES HAULING CONDITIONS ) | 103 | 118 | 122 | 113 | 111 | 109 | 107 | 101 | 92 | 84 | 124 | 115 |
| REAR DUMP TRUCK | 2000 RPM ( ASSUMES HAULING CONDITIONS) | 105 | 116 | 117 | 112 | 110 | 109 | 106 | 102 | 93 | 85 | 121 | 114 |
| REAR DUMP TRUCK | 2000 RPM ( ASSUMES HAULING CONDITIONS ) | 104 | 112 | 116 | 112 | 111 | 109 | 108 | 102 | 93 | 85 | 120 | 114 |
| REAR DUMP TRUCK | 2000 RPM ( ASSUMES HAULING CONDITIONS ) | 101 | 115 | 116 | 111 | 109 | 107 | 105 | 99 | 89 | 82 | 120 | 112 |
| REAR DUMP TRUCK | 2000 RPM ( ASSUMES HAULING CONDITIONS ) | 100 | 114 | 118 | 110 | 108 | 107 | 103 | 98 | 93 | 85 | 121 | 112 |
| REAR DUMP TRUCK | 2000 RPM ( ASSUMES HAULING CONDITIONS ) | 100 | 113 | 118 | 110 | 110 | 107 | 103 | 98 | 90 | 84 | 121 | 112 |
| REAR DUMP TRUCK | 2000 RPM ( ASSUMES HAULING CONDITIONS ) | 102 | 117 | 121 | 110 | 108 | 106 | 104 | 98 | 88 | 82 | 123 | 112 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 110 | 111 | 107 | 94 | 99 | 95 | 92 | 86 | 78 | 70 | 115 | 101 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 105 | 110 | 104 | 95 | 97 | 96 | 95 | 87 | 78 | 69 | 112 | 101 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 107 | 114 | 107 | 94 | 96 | 93 | 91 | 84 | 78 | 71 | 116 | 99 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 100 | 113 | 105 | 93 | 96 | 94 | 88 | 85 | 69 | 70 | 114 | 99 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 103 | 110 | 101 | 94 | 98 | 100 | 94 | 87 | 78 | 70 | 112 | 103 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 105 | 109 | 99 | 92 | 99 | 95 | 90 | 85 | 76 | 71 | 111 | 100 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 114 | 114 | 108 | 96 | 97 | 94 | 92 | 85 | 77 | 70 | 118 | 100 |
| LIGHTING TOWER | NORMAL OPERATING CONDITIONS | 102 | 104 | 105 | 102 | 95 | 97 | 98 | 93 | 90 | 85 | 110 | 103 |

| OTHER SOURCES MEASURED BY WORSLEY | OPERATING CONDITIONS TESTED | OCTAVE BAND NOISE POWER IN dB(lin) | | | | | | | | | | TOTAL NOISE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 22.5 TO 45 Hz | 45 TO 90 Hz | 90 TO 180 Hz | 180 TO 355 Hz | 355 TO 710 Hz | 710 TO 1400 Hz | 1400 TO 2800 Hz | 2800 TO 5600 Hz | 5600 TO 11200 Hz | 11200 TO 22400 Hz | LIN | AWT |
| FRONT END LOADER | IDLE ( ASSUMES STANDBY SITUATION ) | 99 | 106 | 102 | 95 | 97 | 98 | 94 | 87 | 79 | 71 | 109 | 101 |
| SECONDARY CRUSHER | PEAK OPERATION | 119 | 116 | 117 | 119 | 122 | 110 | 109 | 103 | 95 | 91 | 126 | 121 |
| KOMATSU D475 BULLDOZER | RIPPING OPERATION | 104 | 115 | 113 | 111 | 113 | 109 | 107 | 103 | 98 | 93 | 120 | 115 |
| KOMATSU D455 BULLDOZER | ASSIST LOADING OPERATION | 104 | 108 | 114 | 114 | 112 | 110 | 109 | 106 | 102 | 100 | 120 | 116 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 106 | 109 | 103 | 96 | 101 | 102 | 95 | 86 | 78 | 72 | 112 | 104 |
| REAR DUMP TRUCK | IDLE ( ASSUMES STANDBY SITUATION ) | 110 | 114 | 108 | 95 | 99 | 94 | 91 | 87 | 80 | 72 | 116 | 101 |
| REAR DUMP TRUCK | HAULING LOADED UPHILL 20Km/h | 102 | 114 | 116 | 112 | 109 | 108 | 105 | 105 | 98 | 93 | 120 | 113 |
| REAR DUMP TRUCK | HAULING LOADED UPHILL 20Km/h | 99 | 118 | 120 | 114 | 111 | 112 | 108 | 108 | 99 | 87 | 124 | 117 |
| REAR DUMP TRUCK | HAULING EMPTY DOWNHILL 60Km/h | 106 | 117 | 118 | 117 | 111 | 105 | 109 | 99 | 91 | 88 | 123 | 115 |
| REAR DUMP TRUCK | HAULING EMPTY DOWNHILL 60Km/h | 115 | 116 | 124 | 119 | 116 | 116 | 115 | 107 | 100 | 89 | 127 | 121 |
| REAR DUMP TRUCK | TIPPING AT PRIMARY CRUSHER | 98 | 114 | 126 | 113 | 118 | 111 | 110 | 104 | 99 | 99 | 127 | 119 |
| REAR DUMP TRUCK | REVERSE ALARM - SMART | 82 | 75 | 72 | 76 | 68 | 92 | 80 | 72 | 61 | 47 | 93 | 92 |
| REAR DUMP TRUCK | REVERSE ALARM - PROX | | | | | | 4 | 7 | 56 | 44 | 42 | 4 | |

## Predicted Sound Power Levels at Newest Affected Residences
## Adjusted L10 dB(A) Prediction For Various Wind Speeds, Directions

### Typical Mining Operation Noise Modelling Results

| Wind Direction | Wind Speed | Effected Residence. ( Location as shown in Figures 15, 16 & 17 ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Calm | 0 | 22 | 22 | 15 | 15 | 10 | 10 | 31 | 13 | 15 | 21 |
| Sector 1 | 2.0 | | | | | | 32 | 37 | | 28 | |
| (45deg) | 3.0 | | | | | | 35 | 39 | | | |
| | 4.0 | | | | 26 | | | 42 | 27 | 35 | |
| Sector 2 | 2.0 | | | | | | | | 25 | 31 | |
| (90deg) | 3.0 | | | | | | | | 34 | 35 | |
| | 4.0 | | | | | | | | 38 | | |
| Sector 3 | 2.0 | | | | | | | | 26 | 31 | |
| (135deg) | 3.0 | | | | | | | | 32 | 35 | |
| | 4.0 | | | | | | | 35 | 38 | | 32 |
| Sector 4 | 2.0 | 32 | | | | | | 29 | | | 35 |
| (180deg) | 3.0 | 35 | 27 | | | | | 28 | | | 37 |
| | 4.0 | 39 | 31 | | | | | 28 | 30 | 30 | 39 |
| Sector 5 | 2.0 | 37 | 33 | | | | | | | | 36 |
| (225deg) | 3.0 | 39 | 35 | | | | | | | | 38 |
| | 4.0 | 42 | | 25 | | | | | | | 40 |
| Sector 6 | 2.0 | 37 | 34 | 24 | 28 | | | | | | 34 |
| (270deg) | 3.0 | | 37 | 26 | 29 | | | | | | 36 |
| | 4.0 | 43 | | 29 | 31 | 28 | | | | | 37 |
| Sector 7 | 2.0 | 35 | 34 | | 30 | 22 | 30 | | | | |
| (315deg) | 3.0 | | 36 | | 32 | | | 29 | | | |
| | 4.0 | 40 | | 28 | | 28 | | | | | 22 |
| Sector 8 | 2.0 | | | | 28 | | 33 | | | | |
| (0deg) | 3.0 | | | | 30 | | 36 | 36 | | | |
| | 4.0 | 28 | 33 | 23 | 31 | 22 | | 37 | 24 | | |

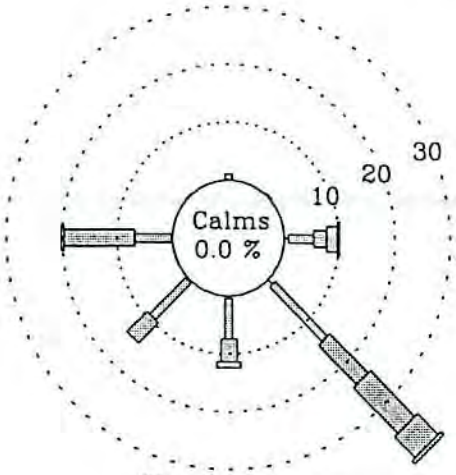
### Retracted Operation Noise Modelling Results

| Wind Direction | Wind Speed | Affected Residence. ( Location as shown in Figures 15, 16 & 17 ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Calm | 0 | | | | | | | | | | |
| Sector 1 | 2.0 | | | | | | | | | | |
| (45deg) | 3.0 | | | | | | | | | | |
| | 4.0 | | | | | | | 36 | | | |
| Sector 2 | 2.0 | | | | | | | | | | |
| (90deg) | 3.0 | | | | | | | | 34 | | |
| | 4.0 | | | | | | | | 38 | | |
| Sector 3 | 2.0 | | | | | | | | | | |
| (135deg) | 3.0 | | | | | | | | | | |
| | 4.0 | | | | | | | | | | |
| Sector 4 | 2.0 | | | | | | | | | | |
| (180deg) | 3.0 | 33 | | | | | | | | | |
| | 4.0 | 38 | | | | | | | | | 33 |
| Sector 5 | 2.0 | 33 | 32 | | | | | | | | |
| (225deg) | 3.0 | 36 | | | | | | | | | |
| | 4.0 | | | | | | | | | | 33 |
| Sector 6 | 2.0 | | | | | | | | | | |
| (270deg) | 3.0 | 35 | 35 | | | | | | | | |
| | 4.0 | | | | | | | | | | 29 |
| Sector 7 | 2.0 | 30 | 29 | | | | | | | | |
| (315deg) | 3.0 | 31 | | | | | | | | | |
| | 4.0 | | | | | | | | | | |
| Sector 8 | 2.0 | | | | | | | | | | |
| (0deg) | 3.0 | | | | | | 32 | | | | |
| | 4.0 | | | | | | 33 | 32 | | | |

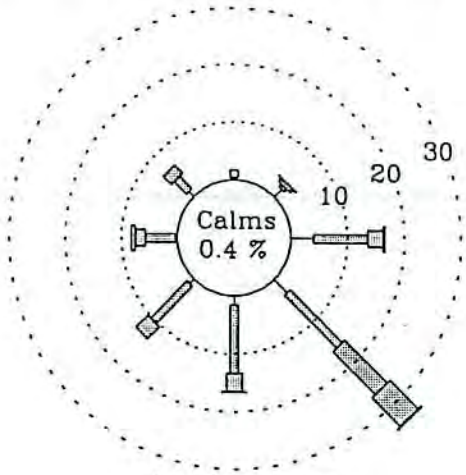
### Fallback Operation Noise Modelling Results

| Wind Direction | Wind Speed | Affected Residence. ( Location as shown in Figures 15, 16 & 17 ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Calm | 0 | | | | | | | | | | |
| Sector 1 | 2.0 | | | | | | | 29 | | | |
| (45deg) | 3.0 | | | | | | | 31 | | | |
| | 4.0 | | | | | | 31 | 34 | 20 | | |
| Sector 2 | 2.0 | | | | | | | | | | |
| (90deg) | 3.0 | | | | | | | 29 | 33 | | |
| | 4.0 | | | | | | | 31 | 37 | 24 | |
| Sector 3 | 2.0 | | | | | | | | | | |
| (135deg) | 3.0 | | | | | | | | 29 | | |
| | 4.0 | | | | | | | | 35 | 28 | |
| Sector 4 | 2.0 | | | | | | | | | | |
| (180deg) | 3.0 | 29 | | | | | | | | | |
| | 4.0 | 36 | 27 | | | | | | | 27 | 26 |
| Sector 5 | 2.0 | | | | | | | | | | |
| (225deg) | 3.0 | 29 | 28 | | | | | | | | |
| | 4.0 | 36 | 35 | | | | | | | | |
| Sector 6 | 2.0 | | | | | | | | | | |
| (270deg) | 3.0 | | | | | | | | | | |
| | 4.0 | | 27 | 23 | 27 | 26 | | | | | |
| Sector 7 | 2.0 | | | | | | | | | | |
| (315deg) | 3.0 | | | | | | | | | | |
| | 4.0 | | | | 31 | 26 | | | | | |
| Sector 8 | 2.0 | | | | | | | | | | |
| (0deg) | 3.0 | | | | | | | | | | |
| | 4.0 | | | | 29 | | 31 | 30 | | | |

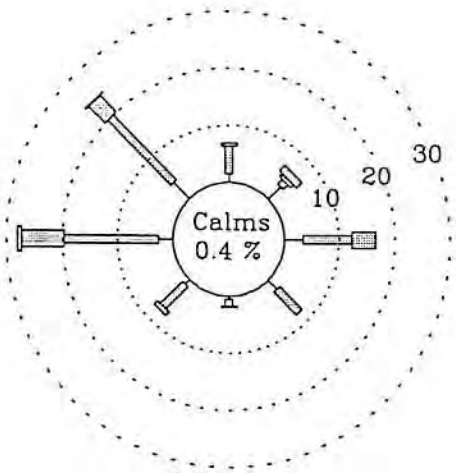
# BAUXITE MINE - 1/9/94 to 31/8/95



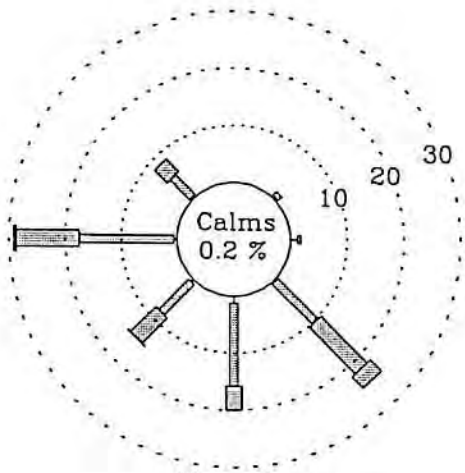

Summer



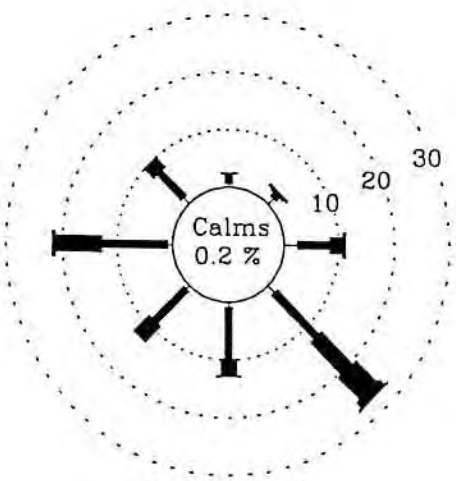

Autumn



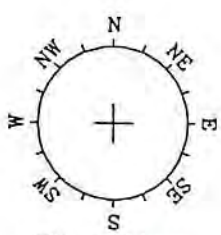

Winter



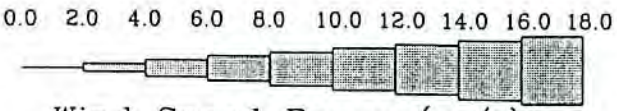

Spring




Annual




Direction

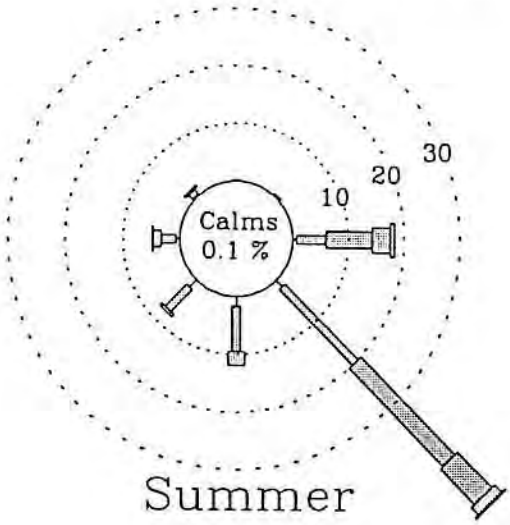



Wind Speed Range (m/s)

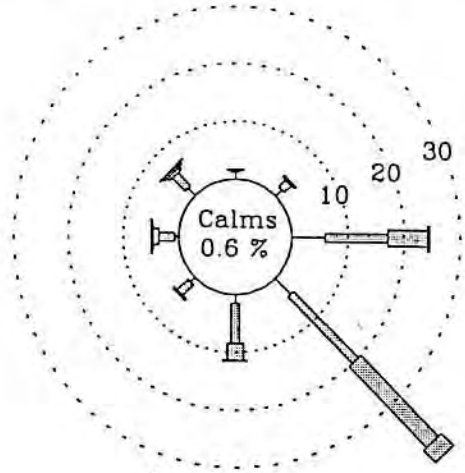
Time Interval : 1900 to 2200

WNI Science & Engineering - 09:44 Dec 7 1995 (WST)Program: rose Source: bauxite.10 Output: PLOT.LAS

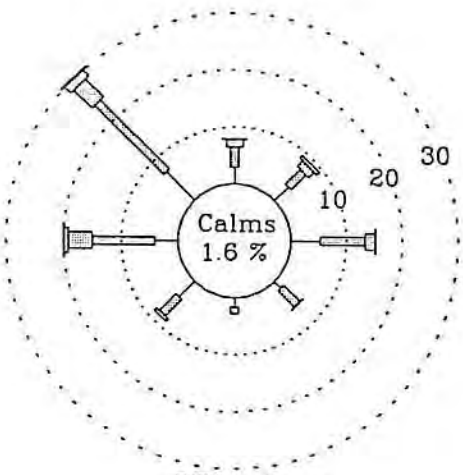
# BAUXITE MINE - 1/9/94 to 31/8/95



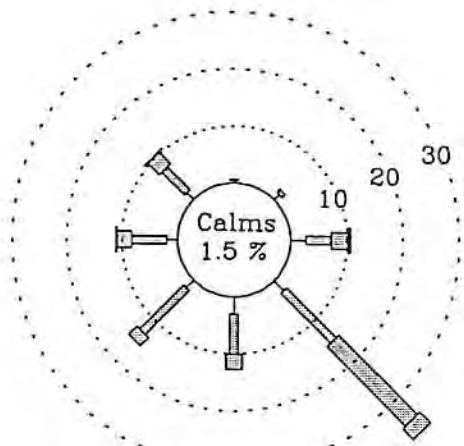

Summer



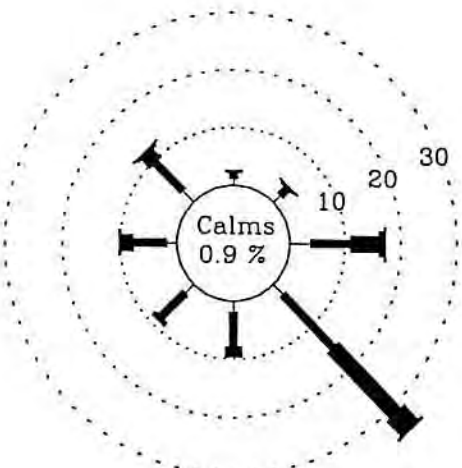

Autumn



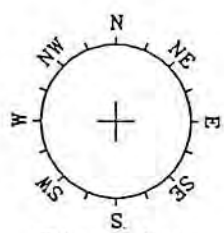

Winter



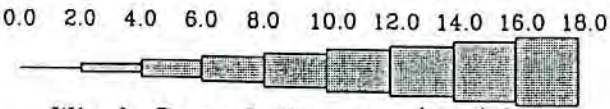

Spring




Annual




Direction

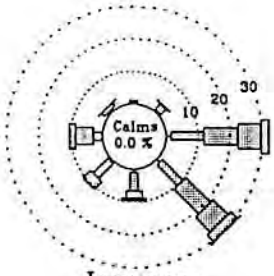



Wind Speed Range (m/s)

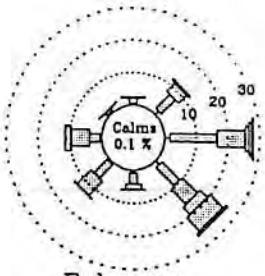
Time Interval : 2200 to 0700

WNI Science & Engineering - 09:45 Dec 7 1995 (WST)Program: rose Source: bauxite.10 Output: PLOT.LAS

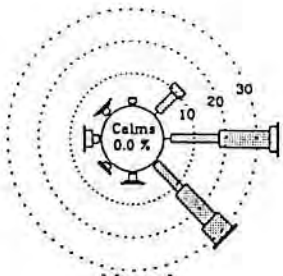
# BAUXITE MINE - 1/9/94 to 31/8/95



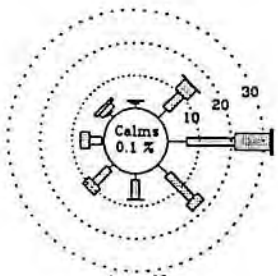
January



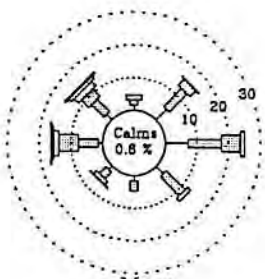
February



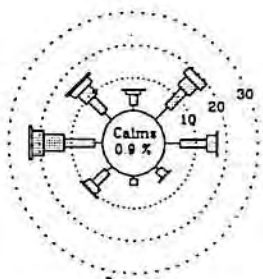
March



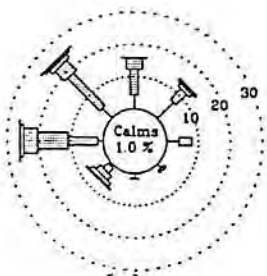
April



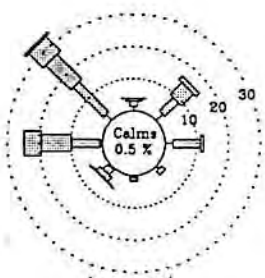
May



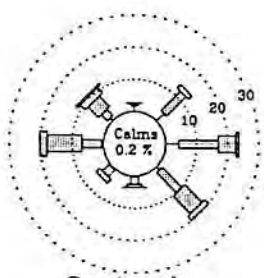
June



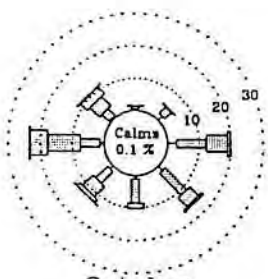
July



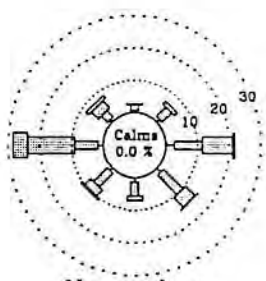
August



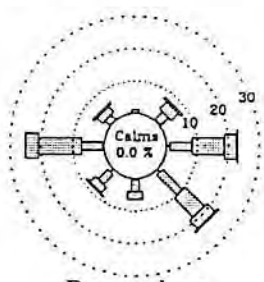
September



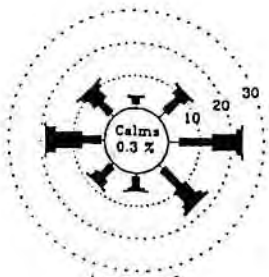
October



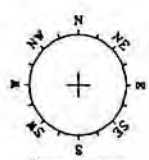
November



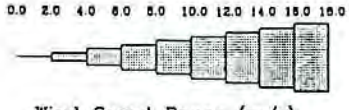
December



Annual



Direction

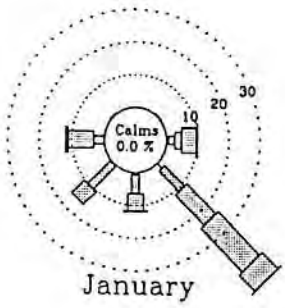


Wind Speed Range (m/s)

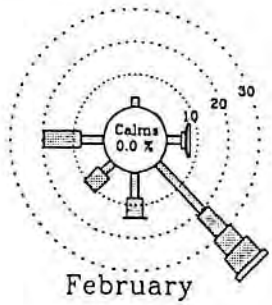
Time Interval : 0700 to 1900

WNI Science & Engineering - 09:40 Dec 7 1995 (WST)Program: rose Source: bauxite.10 Output: PLOT.LAS

# BAUXITE MINE - 1/9/94 to 31/8/95



January



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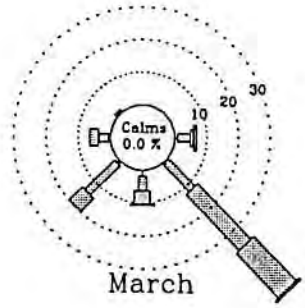

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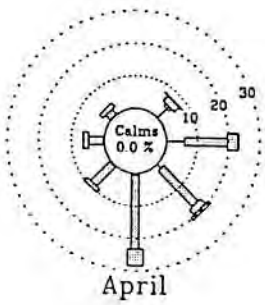

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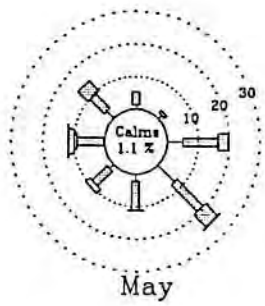

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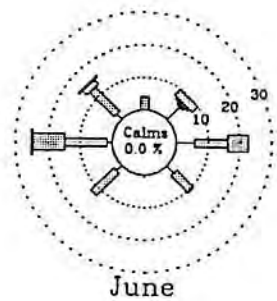

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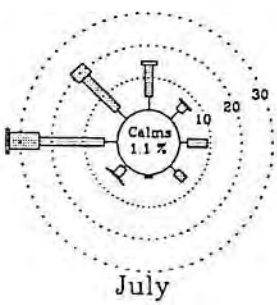

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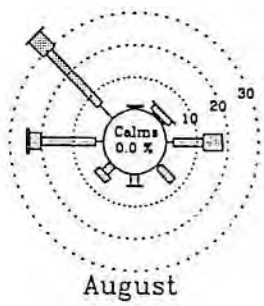

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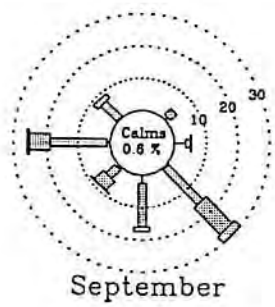

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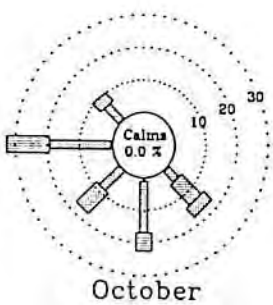

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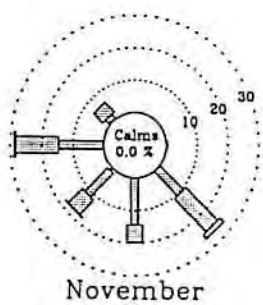

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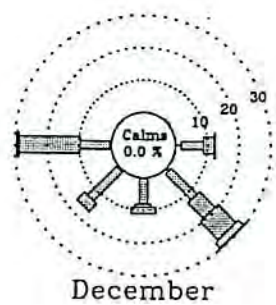

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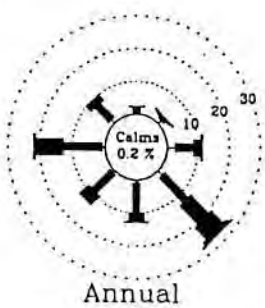

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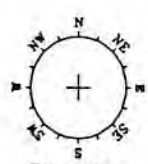

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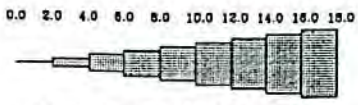
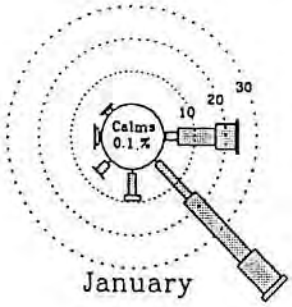


Wind Speed Range (m/s)

Time Interval : 1900 to 2200

WNI Science & Engineering - 09:41 Dec 7 1995 (WST)Program: rose Source: bauxite.10 Output: PLOT.LAS

# BAUXITE MINE – 1/9/94 to 31/8/95



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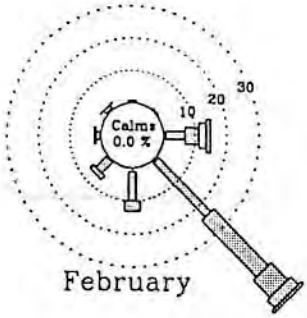

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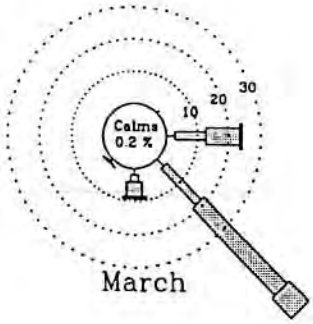

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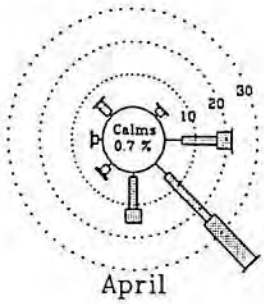

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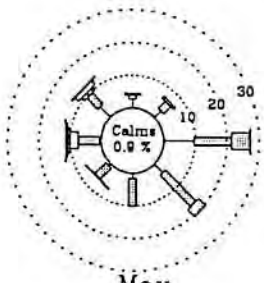

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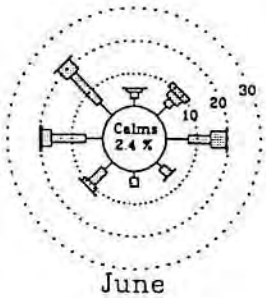

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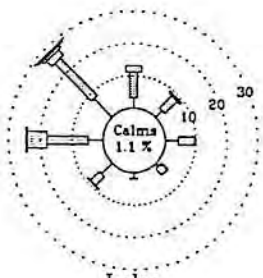

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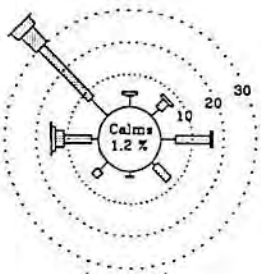

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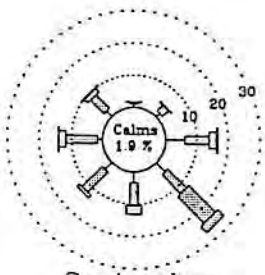

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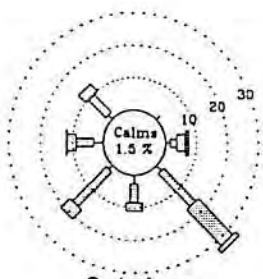

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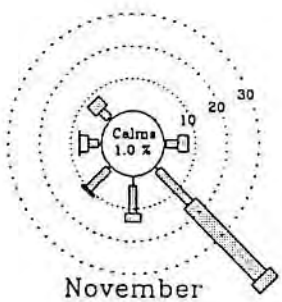

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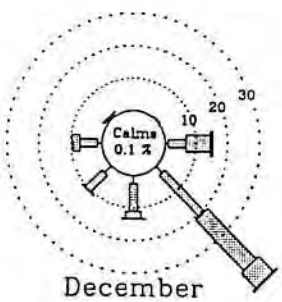

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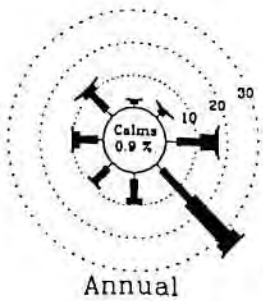

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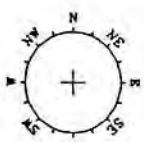

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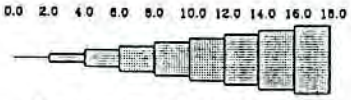

Wind Speed Range (m/s)

Time Interval : 2200 to 0700

WNI Science & Engineering – 09:41 Dec 7 1995 (WST)Program: rose Source: bauxite.10 Output: PLOT.LAS

# APPENDIX 7

# OVERLAND BAUXITE CONVEYOR FOREST DISEASE HYGIENE PRESCRIPTION

# OVERLAND BAUXITE CONVEYOR

# (FOREST DISEASE HYGIENE PRESCRIPTION)

The following is to be included in all work specifications relating to activities conducted outside the established drainage lines along the Worsley Alumina Conveyor Corridor.

## PURPOSE

The purpose of this prescription is to ensure that activities conducted by Worsley Alumina and its contractors do not contribute to the spread of the Jarrah Dieback disease caused by the microscopic soil-borne fungus, *Phytophora cinnamoni.*

## APPLICATION

The prescription applies to all activities requiring operators to move outside the established corridor drainage lines and includes, but is not limited to:

i) servicing and repairs to the 66 Kv transmission line,

ii) drain and culvert maintenance,

iii) treatment and/or removal of trees or shrubs, including forest debris, from corridor,

iv) maintaining fire breaks, or

v) any activities involving earth moving.

## PROCEDURE

The objective of Forest Disease Hygiene is to prevent the movement of soil, root material and water from dieback-infected to dieback-free forest, In terms of the Worsley Alumina Conveyor Corridor, this is best achieved by ensuring:

1. All vehicles, plant and equipment which accumulate earth and root material are cleaned-down prior to entry onto the conveyor corridor service road.

   Depending on the nature of the vehicle, plant or equipment, the nature of the material to be removed and the weather conditions prevailing at the time, clean-down may be by use of water (wash-down) or compressed air (as advised by the Environmental Department).

3. All vehicles, plant and equipment which are used outside the corridor drainage lines must be cleaned-down before returning to the corridor service road.

4. In addition, clean-downs must be performed whenever equipment is to be moved from infected into uninfected areas outside of the corridor drainage lines.

Dieback status and clean-down requirements will be indicated in the field by use of the following colour-coded signs:

| | |
|---|---|
| Entry to dieback forest: | YELLOW PLAQUE<br>(no clean-down required) |
| Entry to dieback-free:<br>forest and clean down point | RED PLAQUE<br>(clean-down before proceeding) |

Clean-down carefully performed to ensure no soil or dirt transported out of the dieback area, must take place at plaque before proceeding.

Wash-down shall be performed using high-pressure water treatment sodium hypochlorite (stock solution 13.5% free chlorine litre/100 litres of water) or copper sulphate (30 grams per litres of water), to remove all accumulated soil, rock and material will be scraped off. Part attention shall be paid to blades, cross-members, track-gear wheels, stabiliser pads, wheel arches, brackets, rippers and augers.

Note: The fungicidal capacity of sodium hypochlorite deteriorates rapidly on exposure to sunlight.

Compressed Air - when the vehicle and soil material are dry, compressed air is and acceptable alternative method of clearing. However, some physical brushing maybe necessary.

4. Only rubber tyred vehicles are to be used outside the drainage lines.

5. In the event of a rainfall event of 5mm or more, all earth operations shall cease until approval to proceed is received from the Environmental Department.

6. Where possible, work outside the corridor drainage lines is carried out by hand.

7. No material is to be placed outside of the corridor drainage lines.

8. Any soil or forest debris disposed of from outside of the corridor drainage lines must be transported to a site approved for disposal by the Environmental Department.

9. Corridor drainage lines must be maintained in an operation condition at all times.