# HEDGES GOLD PROJECT

ALCOA OF AUSTRALIA LIMITED

Report and Recommendations
of the
Environmental Protection Authority

Environmental Protection Authority
Perth, Western Australia

Bulletin 314 January 1987

CONTENTS


| | | Page |
|---|---|---|
| i | SUMMARY AND RECOMMENDATIONS | iii |
| 1. | BACKGROUND | 1 |
| 2. | PROJECT DESCRIPTION | 1 |
| 3. | EXISTING ENVIRONMENT AND LAND USE | 4 |
| 4. | PUBLIC AND GOVERNMENT SUBMISSIONS | 4 |
| 5. | ENVIRONMENTAL ASSESSMENT AND MANAGEMENT | 5 |
| 5.1 | FORESTS | 6 |
| 5.2 | RESIDUE DISPOSAL | 7 |
| 5.3 | WATER SUPPLY | 9 |
| 5.4 | SALINITY | 10 |
| 5.5 | REHABILITATION | 10 |
| 5.6 | ATMOSPHERIC EMISSIONS | 12 |
| 5.7 | NOISE | 12 |
| 5.8 | SOCIAL EFFECTS/INFRASTRUCTURE | 12 |
| 5.9 | ABORIGINAL SITES | 13 |
| 5.10 | REPORTING | 13 |
| 6. | CONCLUSIONS AND RECOMMENDATIONS | 14 |


APPENDICES


| | | |
|---|---|---|
| 1 | Review of Submissions | 15 |
| 2 | Proponent's Response to Submissions | 23 |
| 3 | Stream Flow Data | 46 |
| 4 | Proponent's commitments to Environmental Management | 49 |

## FIGURES


| | | Page |
|---|---|---|
| 1. | Hedges Gold Mine General Location . . . . . | 2 |
| 2. | Hedges Gold Mine Project Area . . . . . | 3 |


## TABLES


| | | |
|---|---|---|
| 1. | Submissions Summary . . . . . | 4 |
| 2. | Persons and Organisations who made Submissions . . . . . | 5 |

## i SUMMARY AND RECOMMENDATIONS

Alcoa of Australia (the proponent) has proposed to establish a gold mining operation of up to 2 million tonnes per annum with a project life of 4-5 years. The mine is proposed to be located in State Forest, with processing and waste disposal facilities located on private land. The mine would be adjacent to the currently operating Boddington Gold Mines, and would mine the same ore body.

The proposed mine is located in the eastern, low rainfall section of the Darling Range and also within the catchment area of the 34 Mile Brook. The main environmental issues were associated with salinity, jarrah dieback disease, residue disposal and rehabilitation of the site subsequent to decommissioning.

The Authority has made a number of recommendations which will ensure the environmental acceptability of this proposal. A number of the recommendations are related to the gathering of significant amounts of data, both before and during the operations. Details were required of the biological and geological status of the site and specific recommendations related to mine and haul road design, rehabilitation after mining decommissioning, pumping from the Hotham River and dieback control procedures.

The Authority has recommended environmental controls on cyanide and caustic soda, and has detailed a number of contingency plans which should be adhered to by the proponent.

In this Assessment Report, the Authority has concluded that the proposal is environmentally acceptable and has made the following recommendations:

RECOMMENDATION 1

**The Environmental Protection Authority concludes that the proposal described in the ERMP is environmentally acceptable and recommends that it could proceed subject to the Environmental Protection Authority's recommendations in this Assessment Report and the commitments made by the proponent for environmental management including:**

- **rehabilitation of mined areas;**
- **maintenance of water quality;**
- **control of noise and dust;**
- **monitor environmental impacts and management; and**
- **report results.**

RECOMMENDATION 2

**The Environmental Protection Authority recommends that the proponent comply with hygiene measures for jarrah dieback disease, to the satisfaction of the Department of Conservation and Land Management, in the detailed design and implementation of the project.**

RECOMMENDATION 3

The Environmental Protection Authority recommends that the alignment of the haul road in State Forest be to the satisfaction of the Department of Conservation and Land Management.

RECOMMENDATION 4

The Environmental Protection Authority recommends that a biological baseline report should be prepared and submitted to the Environmental Protection Authority prior to commissioning of the plant. Any changes from the biological baseline, as determined by an ongoing biological monitoring programme, and any consequent changes to management, should be documented and provided to the Environmental Protection Authority for assessment.

RECOMMENDATION 5

The Environmental Protection Authority recommends that no cyanide from the tailings is to be discharged to surface waters downstream of the tailings dam.

RECOMMENDATION 6

The Environmental Protection Authority recommends that the proponent use low mercury caustic soda in which the mercury level does not exceed those limits set for the use of caustic soda in the alumina industry under in Western Australia.

RECOMMENDATION 7

The Environmental Protection Authority recommends that the proponent submit the tailings dam design including safety features, recovery systems and under drain design to the Environmental Protection Authority, the Department of Mines and the Water Authority of Western Australia and that dam construction be prohibited until such design be found to be acceptable.

The Environmental Protection Authority further recommends that a groundwater monitoring programme be developed by the proponent and approved by the Environmental Protection Authority before commissioning of the tailings dam. The groundwater monitoring programme should include:

- measurements of dissolved salts, pH and cyanide;
- monitoring results and notification to the Environmental Protection Authority of any detected seepage, and
- proposals of remedial action, to the Environmental Protection Authority's satisfaction, in the event that seepage is detected.

RECOMMENDATION 8

The Environmental Protection Authority recommends that pumping from the Hotham River should only take place when the river flow is in excess of 342 kilolitres per hour. Total pumping from the river should not cause the remaining flow to be reduced below a flow of 342 kilolitres per hour (River flow measured at Marradong River bridge gauging station). The proponent should negotiate agreements, to the satisfaction of the Minister for Water Resources, with any other major user of water from the Hotham River in order

to ensure that overall pumping does not reduce flow below 342 kilolitres per hour.

The Environmental Protection Authority further recommends that the minimum flow rate of 342 kilolitres per hour should be reviewed by the Water Authority of Western Australia after two winter flows and advice given to the Environmental Protection Authority as to whether this rate is having undesirable environmental impacts.

RECOMMENDATION 9

The Environmental Protection Authority recommends that the proponent conducts hydrological studies to determine changes in salinity in surface and groundwater arising from mining operations. A programme for such studies should be submitted to the Environmental Protection Authority for approval prior to commissioning.

RECOMMENDATION 10

The Environmental Protection Authority recommends that the proponent presents proposals for rehabilitation of areas affected by the project within 12 months of commissioning, as follows:

- rehabilitation of landscape, soils and vegetation appropriate for the land use priority for that area and to standards appropriate to bauxite mining, to the satisfaction of the Department of Conservation and Land Management;

- rehabilitation of areas affected by chemical spills should they occur and monitoring of chemical concentrations until they decline to background levels;

- rehabilitation of haul roads in State Forest, to the satisfaction of the Department of Conservation and Land Management;

- rehabilitation of the water supply dam, to the satisfaction of the Water Authority of Western Australia; and

- rehabilitation of the tailings dam, to the satisfaction of the Department of Mines.

The Environmental Protection Authority further recommends that with the exception of the material used in road construction, mine waste be returned as backfill to mine pits during the life of the project. If it is decided not to process marginal ore, this material should also be returned to mined out pits. Should a decision to mine bedrock be made in the future, then detailed plans must be submitted to the Environmental Protection Authority for further assessment.

RECOMMENDATION 11

The Environmental Protection Authority recommends that Alcoa ensures that noise levels generated by blasting operations do not exceed 115 dB peak linear and that noise levels from machinery will be set during works approval and licencing under the Environmental Protection Act, 1986.

RECOMMENDATION 12

The Environmental Protection Authority recommends that the proponent produce an environmental management programme to the satisfaction of the Environmental Protection Authority, prior to each separate construction or development stage being implemented. These reports should be consolidated into a document suitable for public information and include information provided subsequent to Recommendations 2, 3, 7, 9 and 10.

RECOMMENDATION 13

The Environmental Protection Authority recommends that the proponent provide decommissioning plans for:

. the tailings dam;

. the water supply dam, and

. the removal of waste and equipment.

Plans should be finalised at least twelve months prior to the proposed date for decommissioning and be approved by the Environmental Protection Authority and appropriate Government agencies.

## 1. INTRODUCTION

Alcoa of Australia Limited has mined bauxite in the western Darling Range since 1963. The first indication of base metal and gold mineralisation was made by the Geological Survey of Western Australia in 1978, mainly in the Hedges forest block, near the eastern boundary of Alcoa's Mineral Lease located 100 km south-east of Perth, 12 km north-west of Boddington, immediately west of and adjoining the Boddington Gold Mine (BGM). The location is shown in Figures 1 and 2.

Feasibility studies were carried out in 1986 and 1987. Alcoa of Australia Limited has proposed a gold mining operation of up to 2 million tonnes per annum (tpa) with a project life of 4-5 years. The mine is located near the eastern boundary of Alcoa's Mineral Lease located 100 km south-east of Perth and 12 km north-west of Boddington. The main features of the project are the mine, processing, water supply reservoir, tailings dams and power supply. All are within the catchment of 34 Mile Brook, a tributary of the Hotham River. Most of the mine site would be in State Forest, with the mine processing plant, including carbon-in-leach processing plant, water storage dam and tailings dam being located on private land. 34 Mile Brook has been identified by the WA Water Authority as a potential public water supply source because of its low salinity.

This assessment report considers the information provided in the Environmental Review and Management Programme (ERMP) that was prepared for this proposal together with submissions from the public and Government Departments and further details provided by Alcoa. Issues discussed include flora and fauna, forest disease, residue disposal, salinity, downstream water supply, rehabilitation, social effects and reporting. The main requirement of project environmental management will be the long term maintenance of the 34 Mile Brook water quality. Assessment of environmental issues has been made more straightforward because of the issues identified during the Environmental Protection Authority's Assessment of Worsley Alumina Pty Ltd's existing Boddington Gold Mine, which shares the same ore body. There is therefore an expectation by the Environmental Protection Authority that environmental management standards should be the equivalent of those set for the Boddington Gold Mine.

## 2. PROJECT DESCRIPTION

Alcoa proposes to mine and process up to 2 million tonnes per annum (tpa) of lateritic gold ore from the Hedges deposit, which is located in State Forest 4 km south of Mt Wells and 12 km north west of the town of Boddington. The life of the mining operation will be at least 4 years. As the deposit occurs on one side of a ridge, the mine will be developed as a series of benches.

The carbon-in-leach processing plant, water storage dam and tailings dam will be located on private land owned by the Worsley Timber Company. Ore will be hauled from the mine to the plant, using a 6.75 km haul road of which 5.75 km will need to be constructed in State forest.

Alcoa intends to construct a water supply dam on a tributary of 34 Mile Brook. A limited amount of water will be collected from the tributary catchment. However, the majority of the water supply would need to be drawn from the Hotham River. Power will be provided via a 22 kV transmission line from the Boddington Gold Mine and a 5 km access road will be constructed on Worsley Timber Company Land.

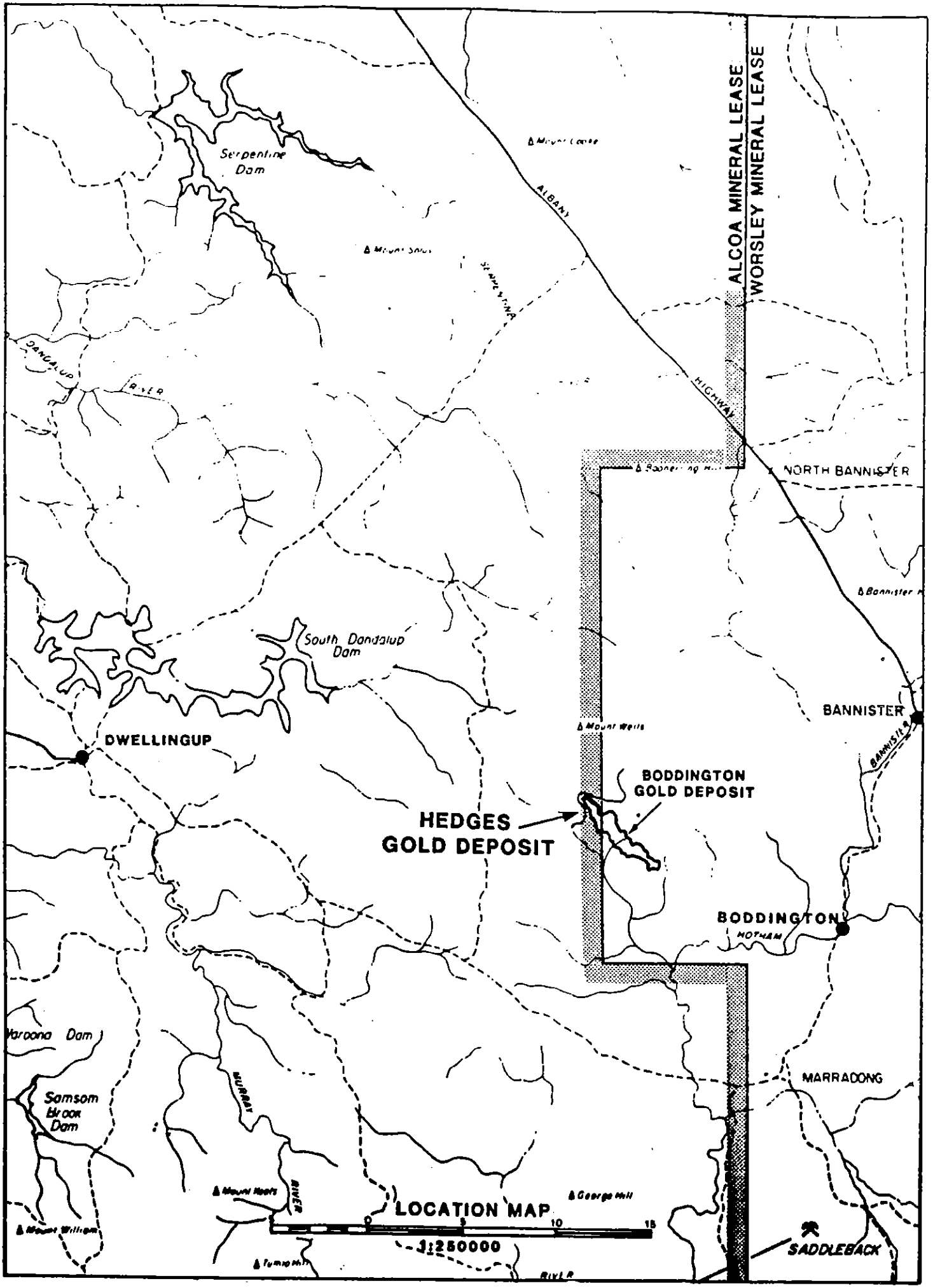


Figure 1. Hedges Gold Mine General Location.

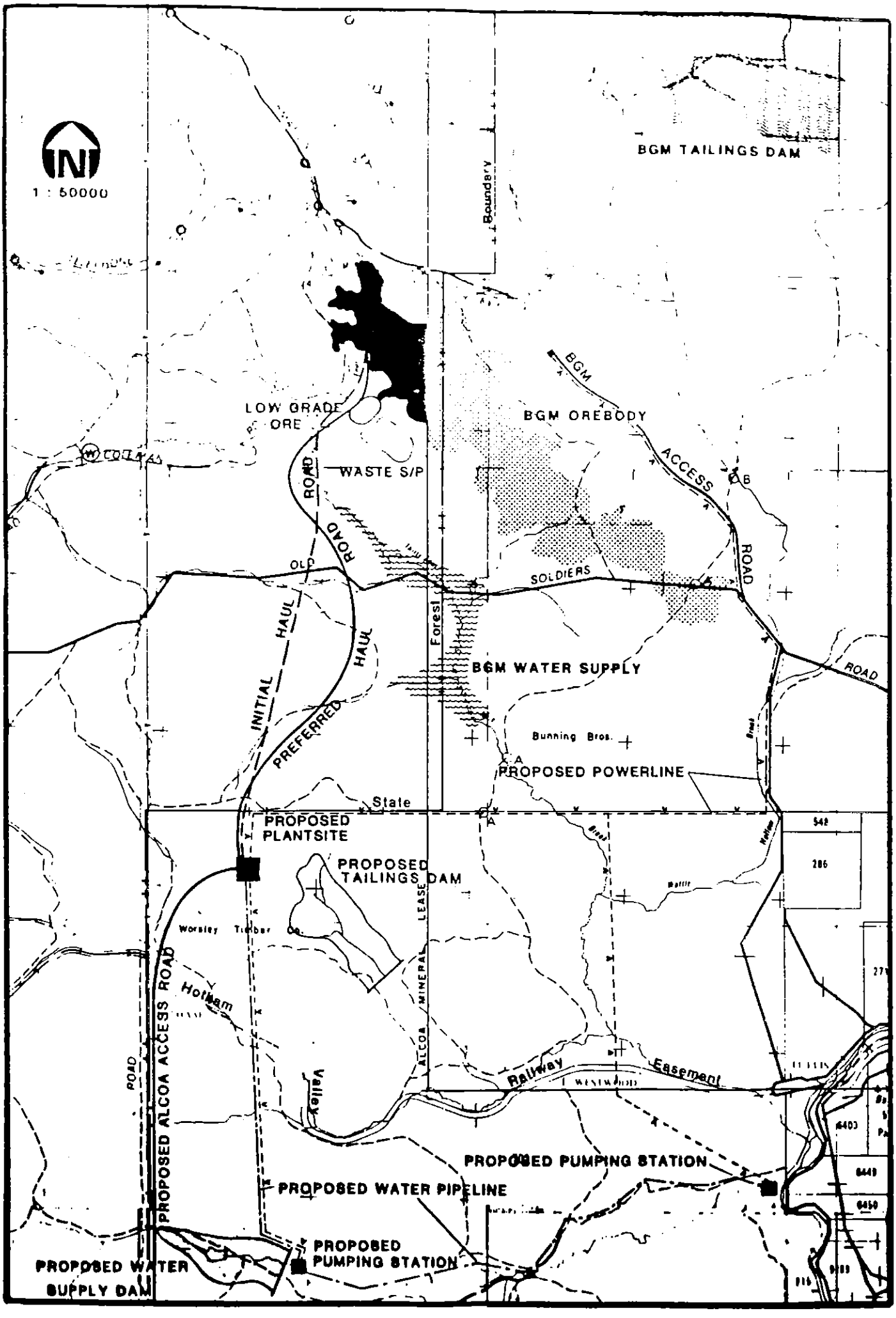


Figure 2. Hedges Gold Mine Project Area.

It is intended that an estimated 95 people will be employed during the construction phase, and 80 during the operating phase. It is anticipated that these people will reside in the Boddington, Pinjarra, Dwellingup and Mandurah areas.

## 3. EXISTING ENVIRONMENT AND LAND USE

The proposed Hedges Gold Mine is located in the eastern fringe of the jarrah forest and approximately 35 km from the Darling Scarp. The area is dissected by 34 Mile Brook, which flows intermittently into the Hotham River. The valleys associated with 34 Mile Brook and its tributaries are generally broad and relatively shallow.

The soils of the area include the Dwellingup, Cook and Pindalup units but generally vary from course textured lateritic gravels of the upper slopes and ridges, gradually becoming finer downslope to the finely textured sandy yellow and grey soils of the broad valley floors.

Climate is typically mediterranean, with an estimated average rainfall of 810 mm. Over 50% of rain falls in winter and less than 10% in summer. Temperatures range from an average daily maximum of over 30 $^{o}$C in summer, to an average daily minimum of less than 5 $^{o}$C in winter.

Land use priority proposed in the Department of Conservation and Land Management's Regional Management Plan is catchment protection. Although the Hotham River system is saline, 34 Mile Brook is considered by the Water Authority to be a possible future potable water source.

The Hedges forest block is jarrah-marri forest, and is in the dieback Disease Risk Area. Vehicular access without a permit is illegal.

There has been extensive consideration of the need for conservation areas in the Jarrah Forest and in recent times. The Monadnocks Reserve and the eastern part of the Lane-Poole Reserve have been set aside as representative of the eastern Jarrah Forest.

## 4. PUBLIC AND GOVERNMENT SUBMISSIONS

Ten public submissions and seven responses from State and Commonwealth agencies were received during the public review period. A summary of the respondents and issues raised is provided at Tables 1 and 2.

Table 1. Submissions Summary.

| NO OF SUBMISSIONS | ISSUE |
|---|---|
| 7 | tailings dam/water resources |
| 11 | hydrology |
| 8 | salinity |
| 7 | jarrah dieback |
| 5 | social and environmental impacts |
| 8 | infrastructure/access |
| 3 | hazardous chemicals |
| 2 | air pollution |
| 3 | joint venture |
| 7 | rehabilitation |
| 2 | biological infrastructure |
| 1 | mine pit infrastructure |

Table 2. Submissions Received.

GOVERNMENT DEPARTMENTS

Western Australian Museum
Main Roads Department
State Energy Commission
Water Authority of Western Australia
Department of Resources Development
Mines Department
Department of Conservation and Land Management
State Planning Commission

PUBLIC

Campaign to Save Native Forests
Australian Conservation Foundation
Worsley Alumina Pty Ltd
Boddington Shire Council
Mr D Harper
Mrs S Edwards
St John Ambulance (Boddington Sub centre)
Shire of Murray
Mr P Hine
Mr G Mawson

The predominant concerns were mainly with regard to tailings dam/water resources, hydrology, salinity, jarrah dieback, social and environmental impacts, infrastructure, biological information, the mine pit, hazardous chemicals, air pollution, the possibility of a joint venture with the operators of the existing Boddington Gold Mine and rehabilitation. A detailed review of submissions is included in Appendix 1.

Alcoa have addressed the issues raised by the public and Government agencies in their submissions and by the Authority. Alcoa's response is at Appendix 2.

## 5. ENVIRONMENTAL IMPACT ASSESSMENT

This project has several potential environmental impacts because of the location in a forested catchment. The Environmental Protection Authority considered that an ERMP would be required to adequately assess the proposal. After a careful review of the potential environmental impacts of the project, the proposals for management in the ERMP, and the input from public and from controlling bodies, the Environmental Protection Authority has found the proposal to be environmentally acceptable, subject to a series of controls and conditions.

### RECOMMENDATION 1

**The Environmental Protection Authority concludes that the proposal described in the ERMP is environmentally acceptable and recommends that it could proceed subject to the Environmental Protection Authority's recommendations in this Assessment Report and the commitments made by the proponent for environmental management including:**

- **rehabilitation of mined areas;**
- **maintenance of water quality;**

. control of noise and dust;

. monitor environmental impacts and management, and

. report results.

The Hedges gold deposit is an extension of that part of the Worsley Boddington gold deposit which extends on to ground held by Alcoa under the Alumina Refinery Agreement Act. In order to confirm Alcoa's right to gold, as well as to bauxite in that area, an amendment has been made to the Alumina Refinery Agreement to provide for an All Mineral Act Lease to be issued to Alcoa over the Hedges deposit. The environmental performance of the Company under the Mining Lease will be guaranteed by the Company under its Agreement Act.

## 5.1 FORESTS

A total of 38 families, 93 genera and 180 vascular plant species were recorded, probably representing 60-70 % of the flora species in the whole project area. None of the species is officially gazetted as "rare flora", However eleven species have been mentioned in various publications as being either rare, vulnerable, restricted, poorly collected or in need of further research or monitoring. Thirteen site-vegetation types were defined and mapped. In general, the area supports a range of site vegetation types which reflects both the western higher rainfall forest of jarrah and the eastern influence with wandoo in the valley systems. The Carpet Snake and Western Quoll, gazetted as rare or otherwise in need of special protection are locally common in the north eastern parts of the Darling Range. Care should be taken to avoid disturbing their habitats.

The area has been logged in the past (mine site 1940-49 and remainder of State Forest 1920-29). The Hedges forest block was last burnt in spring 1984 and dieback mapping was carried out in 1983.

The mine proposal has been examined by the Department of Conservation and Land Management who have suggested certain conditions including backfilling of the pit with low grade ore, re-aligning the haul road and making commitments to jarrah dieback control.

The Hedges project includes areas quarantined under the Forest Diseases Act Regulations 1975. The ERMP acknowledges the risk which dieback poses to the forest downslope of operation (80 ha) and to other forest nearby if the movement of infected soil and drainage is not controlled. Even the most conscientious application of hygiene may not fully eliminate this. Alcoa have proposed following the Forest Improvement Rehabilitation Scheme (FIRS) treatments, as developed by the Department of Conservation and Land Management.

**RECOMMENDATION 2**

**The Environmental Protection Authority recommends that the proponent comply with hygiene measures for jarrah dieback disease, to the satisfaction of the Department of Conservation and Land Management, in the detailed design and implementation of the project.**

Jarrah Dieback proliferation can be largely affected by the construction programme and by drainage control, especially on the haul road alignment.

RECOMMENDATION 3

**The Environmental Protection Authority recommends that the alignment of the haul road in State Forest be to the satisfaction of the Department of Conservation and Land Management.**

A fauna study was conducted by the proponent in May 1987 and concluded that the likely presence of a number of rare species needs to be considered.

As 34 Mile Brook is only seasonal and flows for perhaps 3 or 4 months of the year, aquatic fauna is not extensive. Aquatic invertebrate fauna is expected to be highly diverse. Alcoa has commissioned detailed consultants reports on the flora and fauna of the Hedges Project Area.

Nevertheless, the Authority considers that details of ecological associations including baseline fauna studies are incomplete and accordingly makes the following recommendations.

RECOMMENDATION 4

**The Environmental Protection Authority recommends that a biological baseline report should be prepared and submitted to the Environmental Protection Authority prior to commissioning of the plant. Any changes from the biological baseline, as determined by an ongoing biological monitoring programme, and any consequent changes to management, should be documented and provided to the Environmental Protection Authority for assessment.**

## 5.2 RESIDUE DISPOSAL

The Water Authority of Western Australia has stressed the future water supply potential of 34 Mile Brook. 34 Mile Brook is also in the catchment of the recreationally important Murray River. As a result of the water resource importance of the 34 Mile Brook. It is important that long term water quality is not impaired by the presence of the residue disposal areas.

The proponent proposes a residue disposal system which includes a tailings dam with a final surface area of about 90 ha on private land. Due to the relatively short life of the operation and operating cost advantages, the proponent proposes a 'wet' slurry disposal method.

At the point of discharge the tailings slurry is predicted to contain 100-150 ppm cyanide, 40 ppm sodium hydroxide and 20 000 ppm total dissolved solids.

The cyanide concentration is significantly reduced through exposure to ultra-violet light and oxidizing conditions.

RECOMMENDATION 5

**The Environmental Protection Authority recommends that no cyanide from the tailings is to be discharged to surface waters downstream of the tailings dam.**

Disposal of gold tailings containing cyanide would be within an impoundment designed and managed such that natural degradation of cyanide is maximised through the processes of solar irradiation, oxidation, adsorption and complexing. Decant water would be collected in a pond and continuously recycled from the tailings pond to the gold processing plant. All pipework would be located within the immediate tailings dam catchment area and any

spillage from leaks or breakage would be contained. The pipeline formation would be constructed such that lateral spread of spillages was prevented.

During the processing of the gold ore around 2 kilograms per tonne of caustic soda and up to 300 parts per million of a viscosity modifying agent will also be added. To minimise the accumulation of mercury in the residue, the proponent should use low mercury caustic soda, according to the principles adopted by the alumina industry.

RECOMMENDATION 6

**The Environmental Protection Authority recommends that the proponent use low mercury caustic soda in which the mercury level does not exceed those limits set for the use of caustic soda in the alumina industry in Western Australia.**

Alcoa proposes a range of design construction and operation measures to avoid pollution due to spillages and/or leakage from the tailings system. However, there is much uncertainty with regard to design of the tailing dam and its associated security. There are problems with containment of tailings and associated liquors and with a possibility of significant quantities of leachates escaping from the dam. The clay layers beneath the proposed dam site are unlikely to be impermeable.

Following closure of the operation, rehabilitation of the tailings dam would be undertaken and vegetation cover would be established to minimise surface runoff and turbid water release into streams. Top soil material, stockpiled during earlier clearing operations, would be respread to facilitate growth of vegetation. Subsoils would be deep ripped where necessary. Ongoing monitoring would be undertaken to ensure that surface drainage water is not contaminated.

The proponent has made a commitment to keep abreast of new technology relating to treatment of cyanide in effluent and to establish surface contouring and drainage to prevent the rise of contaminated waters in residue areas during rehabilitation, and permit vegetation establishment. In addition, the proponent has made a commitment to establish a drainage collection system to retain runoff so that it can be monitored and if necessary treated prior to discharge.

RECOMMENDATION 7

**The Environmental Protection Authority recommends that the proponent submit the tailings dam design including safety features, recovery systems and under drain design to the Environmental Protection Authority, the Department of Mines and the Water Authority of Western Australia and that dam construction be prohibited until such design be found to be acceptable.**

**The Environmental Protection Authority further recommends that a groundwater monitoring programme be developed by the proponent and approved by the Environmental Protection Authority before commissioning of the tailings dam. The groundwater monitoring programme should include:**

- **measurements of dissolved salts, pH and cyanide;**
- **monitoring results and notification to the Environmental Protection Authority of any detected seepage, and**

. **proposals of remedial action, to the Environmental Protection Authority's satisfaction, in the event that seepage is detected.**

## 5.3 WATER SUPPLY

The annual water consumption for the project was estimated at 2000 ML/a. Alcoa propose to pump winter flow from the Hotham River into a storage dam. The water intake is proposed to be located on the west bank of the Hotham River, approximately 1 km downstream from the Boddington Gold Mine intake, on private property (Murray Location 703). Three pumps are proposed, including one on standby, to provide a maximum pumping rate of 2000 kL/hr.

The pumping of water from the Hotham River involves the sharing of this resource between Boddington Gold Mine and Hedges and will be licenced under Section 13 of the Rights in Water and Irrigation Act.

A minimum allowable flow rate of 246 ML/month (equivalent to 342 kL/h) has been determined by the Water Authority of Western Australia in consultation with the Environmental Protection Authority which would allow the environmental impacts of pumping from the Hotham River to be managed. This rate of flow is monitored on a continuous basis at the Marradong Road bridge gauging station by the Water Authority of Western Australia. No pumping may take place whenever flow in the Hotham is below the minimum level to ensure that the environmental values associated with the River are protected.

An application for a licence (as required under the Rights in Water and Irrigation Act (1914) and amendments) to withdraw the required water from the Hotham River has been lodged with the Water Authority.

Alcoa has assumed a combined annual extraction of water from the Hotham River of 4000 ML/a for BGM and 2000 ML/a for Hedges, representing 35% of the recorded minimum annual Hotham River flow of 17 000 Ml (1979) and 5.8% of the average annual flow of 103 000.

RECOMMENDATION 8

**The Environmental Protection Authority recommends that pumping from the Hotham River should only take place when the river flow is in excess of 342 kilolitres per hour. Total pumping from the river should not cause the remaining flow to be reduced below a flow of 342 kilolitres per hour (River flow measured at Marradong River bridge gauging station). The proponent should negotiate agreements, to the satisfaction of the Minister for Water Resources, with any other major user of water from the Hotham River in order to ensure that overall pumping does not reduce flow below 342 kilolitres per hour.**

**The Environmental Protection Authority further recommends that the minimum flow rate of 342 kilolitres per hour should be reviewed by the Water Authority of Western Australia after two winter flows and advice given to the Environmental Protection Authority as to whether this rate is having undesirable environmental impacts.**

In procedural terms, water management and dam construction should be regulated by following the anticipated licensing and Control of Referable Dams provisions of the Rights in Water and Irrigation Act administered by the Water Authority of Western Australia.

## 5.4 SALINITY

The project at Hedges Forest Block is in a salt sensitive area of the eastern forest zone of the north eastern Darling Range where rainfall is less than 900 mm pa and there is a high risk of stream salinity if the natural vegetation is disturbed. There is a risk of causing increased stream salinities to 34 Mile Brook. As is the case with the Boddington Gold Mine, the actual impact will be dependent on the final topography and vegetation of the rehabilitated pits. The Authority notes that the Hedges Gold Project is a proposed short term gold mine. The inherent issues are considered different from those of a large-scale, long term bauxite mining operation such as that at Wagerup. The Environmental Protection Authority notes that the area comprising the Hedges Gold Project has been excised from the Mining Lease 1SA under amendments to the Alumina Refinery Agreement Act (1961), and therefore is not subject to the conditions affecting bauxite mining on that lease. In relation to this, the Environmental Protection Authority considers that from the environmental viewpoint:

- soil, vegetation and salinity conditions are atypical;
- the proposed area is small and localised;
- because of the small area, rehabilitation and environmental protection can be managed; and
- this proposal should be assessed on its own merits.

The 34 Mile Brook has been considered by the Water Authority for development as a water resource some time after the year 2000. As a projected increase of 20% in the salinity of 34 Mile Brook is considered unacceptable, rehabilitation should be designed to reduce this effect.

Increases in salinity are not expected by the proponent to add to present effects on stock watering, stream bed flora and aquatic organisms.

Salinity information for the Hedges project is based on only six bore holes and although extensive data from the Boddington Gold Mine has been extrapolated, there is a lack of appropriate data with respect to long term salinity impacts and estimations of salinity levels after decommissioning.

Because of its importance as a future water resource, it is necessary for the salinity levels in the 34 Mile Brook to remain at acceptable levels.

**RECOMMENDATION 9**

**The Environmental Protection Authority recommends that the proponent conducts hydrological studies to determine changes in salinity in surface and groundwater arising from mining operations. A programme for such studies should be submitted to the Environmental Protection Authority for approval prior to commissioning.**

## 5.5 REHABILITATION

Rehabilitation is proposed to be in accordance with procedures and methods utilised at Alcoa bauxite mines, in agreement with the State and should include the residue storage and processing plant areas.

The rehabilitation process is considered to be important to the future use of 34 Mile Brook as a source of potable water. Given that techniques for

rehabilitation at Hedges will have some differences from those for bauxite mining, a detailed rehabilitation plan is required and should include the shape of the landscape and the anticipated rehabilitation techniques to be used on the disturbed areas.

The objective of management of runoff from mining operations will be to minimise the potential spread of jarrah dieback disease and to avoid any long term salinity and turbidity impacts on 34 Mile Brook.

The shallower pits would be rehabilitated so that slopes are battered to the lowest practicable gradient taking into account the natural landforms and the need to minimise the extent of clearing. Final pit slopes will be determined in consultation with relevant State Government authorities.

In order to assess the effectiveness of the proposed rehabilitation, the State should be provided with rehabilitation proposals, within 12 months of commissioning of the plant. Information should be provided on the flow of water from natural catchments, progress of the mine and an update on whether a decision to mine bedrock has been made. The discussion should include information on remedial action to be taken if rehabilitation objectives are not achieved.

Because this mine has an estimated life of 4-5 years, Alcoa should consider plans for decommissioning of the site, associated waste disposal and water supply areas. Decommissioning plans would require a "walk away solution".

RECOMMENDATION 10

**The Environmental Protection Authority recommends that the proponent presents proposals for rehabilitation of areas affected by the project within 12 months of commissioning, as follows:**

- **rehabilitation of landscape, soils and vegetation appropriate for the land use priority for that area and to standards appropriate to bauxite mining, to the satisfaction of the Department of Conservation and Land Management;**

- **rehabilitation of areas affected by chemical spills should they occur and monitoring of chemical concentrations until they decline to background levels;**

- **rehabilitation of haul roads in State Forest, to the satisfaction of the Department of Conservation and Land Management;**

- **rehabilitation of the water supply dam, to the satisfaction of the Water Authority of Western Australia; and**

- **rehabilitation of the tailings dam, to the satisfaction of the Department of Mines.**

**The Environmental Protection Authority further recommends that with the exception of the material used in road construction, mine waste be returned as backfill to mine pits during the life of the project. If it is decided not to process marginal ore, this material should also be returned to mined out pits. Should a decision to mine bedrock be made in the future, then detailed plans must be submitted to the Environmental Protection Authority for further assessment.**

## 5.6 ATMOSPHERIC EMISSIONS

Gaseous emissions from the processing plant would largely emanate from the Liquid Petroleum Gas fired carbon regeneration kiln and heater. Control methods detailed by the proponent would comply with the Environmental Protection Act (1986).

Emissions from the mining operation would include exhaust from machinery and fugitive dust emissions from haul roads, in-pit access roads and stockpiles. The proponent has made a commitment to control fugitive dust from the Project area. Dust emissions would be minimised by revegetating waste stockpiles where possible and the application of water, bitumen or other effective methods. Fugitive dust generation from ore stockpiles would be prevented by the use of water sprays and appropriate materials handling equipment such as enclosed conveyor belts.

## 5.7 NOISE

The mining and processing operations are both potential noise sources, with most noise coming from mining machinery haulage and blasting operations. The closest inhabited residence is 6 kms away, whilst the town of Boddington is 12 kms away. Neither location should experience any significant noise from either mining or hauling operations.

**RECOMMENDATION 11**

**The Environmental Protection Authority recommends that Alcoa ensures that noise levels generated by blasting operations do not exceed 115 dB peak linear and that noise levels from machinery will be set during works approval and licencing under the Environmental Protection Act, 1986.**

Noise disturbance to faunal populations is expected to be minor and recolonisation would occur after decommissioning and rehabilitation of the mine site. Blasting would be carried out during favourable meteorological periods and nearby populations and relevant State Government agencies would be notified of likely blasting times.

All mobile equipment at the mine site would be fitted with accoustic insulation to protect operators.

## 5.8 SOCIAL EFFECTS/INFRASTRUCTURE

The proposed Hedges Gold Project mine site is situated in State forest and only adjoins private property on the east (Bunning Bros) and south (Worsley Timber Co). The nearest permanent residences are 6 km to the north east, and farm houses to the south east. The nearest residence to plant and tailings facilities of option 3 is about 3 km. Private land uses are predominantly timber production and farm uses.

The Towns of Boddington and Dwellingup are expected to enjoy additional economic and social benefits. While details of access, traffic flow, upgrading of local roads and construction camp site remain unresolved, the proponent expects to finalise these details with the relevant authorities and programmes should be designed with the aesthetic factors of noise and visibility in mind. Access for fire control would be provided for by the proponent and at least one controlled burn of surrounding forest is expected during the life of the mine.

Blasting would be conducted in accordance with standard procedures established in Alcoa's bauxite mining operations, and designed to minimise the impact of blasting on the nearest residence.

## 5.9 ABORIGINAL SITES

The Hedges Gold Project area was surveyed for aboriginal sites, using broad scale surveying with more intense surveys in areas likely to be directly affected.

Two small sites were discovered and suggested transient use of the area. Both sites had been considerably disturbed by past timber cutting operations.

Ethnographic investigations revealed no specific evidence of traditional usage of the area and generally supported the general concept of sparser distribution of stone items and sites in upland areas and/or areas lacking permanent surface water supplies.

The proponent shall ensure that as project planning identifies precise areas of disturbance, the requirements of the Aboriginal Heritage Act (1972-75) in relation to land use be complied with.

## 5.10 REPORTING

In order that the wide range of detailed information required is produced in a logical, coordinated manner, it should be provided the form of an environmental management programme. This would include the information required for licencing under the Rights in Water and Irrigation Act, the proponents environmental management strategy, details of water supply system access the metallurgical treatment plant, residue management and a summary of environmental commitments.

RECOMMENDATION 12

**The Environmental Protection Authority recommends that the proponent produce an environmental management programme to the satisfaction of the Environmental Protection Authority, prior to each separate construction or development stage being implemented. These reports should be consolidated into a document suitable for public information and include information provided subsequent to Recommendations 2, 3, 7, 9 and 10.**

In order that the progress of the environmental management of the project can be efficiently monitored, it is recommended that brief annual reports be prepared for consideration by the Environmental Protection Authority. After three years, a comprehensive report should be prepared and should include plans for decommissioning. The annual reports should comprise a summary of activities undertaken and plans for the next year, together with a comprehensive discussion of the results of the environmental management plan. It would be appropriate for reports to be based on environmental management undertakings and Authority recommendations.

RECOMMENDATION 13

**The Environmental Protection Authority recommends that the proponent provide decommissioning plans for:**

- **the tailings dam;**

. the water supply dam; and

. the removal of waste and equipment.

Plans should be finalised at least twelve months prior to the proposed date for decommissioning and be approved by the Environmental Protection Authority and appropriate Government agencies.

## 6. CONCLUSIONS AND RECOMMENDATIONS

This Assessment Report is submitted to provide an environmental input to decision making on the proposed Hedges Gold Project which is situated 12 km north west of Boddington and adjoining the existing Boddington Gold Mine (BGM). In preparing this Report, the Authority has considered a range of documentation and technical information and has been assisted by contributions from the public and other Government agencies.

The Hedges Gold Project proposes to mine an extension of the ore body presently mined by the Boddington Gold Mine. It is proposed that the Hedges project be a short term operation of about four years. As the adjacent Boddington Gold Mine is already in operation, it is considered that there would be many environmental advantages to having both mines operating concurrently.

Whilst it is acknowledged that mining in the eastern lower rainfall area of the Darling Range must be carefully assessed, the Authority considers that sufficient relevant information was provided to decide that the Hedges Gold Mine proposal would be environmentally acceptable subject to Alcoa implementing the management commitments in their ERMP and respond to submissions (Appendix 4 of this Report) and the Environmental Protection Authority's Recommendations.

APPENDIX 1

REVIEW OF SUBMISSIONS

# REVIEW OF SUBMISSIONS

## 1. TAILINGS DAM/WATER RESOURCES

A number of submissions have expressed concern regarding the absence of geotechnical and hydrological support data with respect to residue disposal.

The proposed tailings dam system is considered to be highly likely to be ineffective with the possibility of significant quantities of leachates escaping from the dam. The proposed cut-off into the claylayers is unlikely to be effective. The recovery systems proposed are unlikely to be fully effective in controlling the toxic wastes.

A hydro-geological report is required, addressing the following points:

- details of the engineering hydrology for the tailings dam, including a detailed study of the structure, mineralogy and chemistry of the impoundment site and design, monitoring and management programme for the tailings dam.

- Details of the effect of the leaching liquor on the lateritic clays base of the impoundment, permeabilities of the profile layers towards vertical as well as horizontal water penetration and the absence of discontinuities and schisms under the impoundment floor should also be included.

- On the basis of the above data, ascertain what structural and sealing measures are necessary and determine the location of any additional monitoring/recovery bores.

- Details of the dam wall construction. The wall slope should not be more than 1:4.

- Details of tailings dam design. It is suggested that the tailings dam capacity be designed to accommodate a 1:100 year flood through the life of operationand at completion. It should also address a "worst case scenario" of groundwater seepage or a burst or overflowed tailings dam. Protection of downstream communities should be included.

- The impact of the failure of the tailings dam structure causing discharge to the Hotham River via 34 Mile Brook should be addressed.

- Details of underdrain design. It is suggested that the underdrain be operated from construction, not after one year as stated in the ERMP.

- Details of geotechnical properties of residues and a comment on how these properties have influenced design of the tailings dam. Why is a 'wet' deposition chosen, when 'dry' seems the best practical technique?

- It is suggested that a suitably designed catch dam, with pump back facilities, or location of the water supply reservoir, be provided downstream of the tailings dam to act as a final reservoir for controlling pollution of the catchment.

REVIEW OF SUBMISSIONS (contd)

- Details of maximum likely levels of CN, Hg and caustic soda to the Hotham river and concern over possible Hg in tailings after decommissioning.

- The level of cyanide in wastes discharging to surface waters downstream of the tailings dam should not exceed 0.1 mg/l.

- Monitoring/recovery bores should be included in the design stage of the dam and should be 50 m (not 250 m) apart. Sites should be determined with a detailed hydrogeological study. Multiport monitoring bores should be considered. Some additional bores are required around the 'shoulders' of the dam and also upstream.

- Monitoring of bores adjacent to the tailings dam should commence at least 6 months before commissioning of the project and shall be 80 mm minimum diameter. Monitoring shall initially be weekly and shall include a continuous water balance study.

- Monitoring is required of the quality and quantify of water discharged from the tailings dam and the water reclaimed from the tailings dam.

- An advisory panel, with WAWA representation, should be established to review water monitoring results and suggest corrective actions if necessary.

2. HYDROLOGICAL

Concerns were expressed in several submissions, mainly in respect to water supply and possible water resource degradation. Further details are required regarding:

- suitable engineering devices to minimise the increased sediment load expected from all parts of the operation.

- Environmental consideration or statement with respect to the effect of water logging on vegetation upstream of the reservoir and the effect of a lack of water downstream of the dam on the native vegetation, especially with respect to Long Gully Creek.

- Potential conflict of interest between BGM and Hedges with regard to pumping from the Hotham River. In addition:

  - the proposed Hedges pump station should also be located at Tullis;

  - a monthly water balance should be produced for the life of the operation to provide an indication of how demand will be met as well as the fate of the water;

  - the method of assessing the retention of the quoted minimum flow over the weir (Marradong Road Bridge WAWA stipulation) when pumping, particularly when BGM is also pumping; and

  - details of the pumping installation.

. Details of the hydrogeology of the water supply dam.

. Further details of the intended sources of potable water.

It is suggested that:

- there should be a commitment that the long term impact of mining operations will not degrade the quality of 34 Mile Brook;

- there should be an agreement to compensate for any long term degradation;

- details are required of proposals to prevent the creek from flowing into the mines area (both in the short and long term), as the preliminary ore outline (Figure 5) shows two places where mining might intersect the creek;

- a commitment to monitor the quality and quantity of 34 Mile Brook should be closely coordinated with the BGM; and

- any domestic waste disposal on the 34 Mile Brook Catchment should be of the self-contained type.

## 3. SALINITY

The problem of salinity was common to many submissions. Because Alcoa have made a previous commitment in their 1978 Wagerup bauxite ERMP that, "mining will not take place in the eastern lower rainfall portion of Alcoa's lease until research shows that mining can be conducted without significantly increasing the salinity of water resources", this quotation has been contrasted with a quote from the Hedges ERMP that, "For the worst cast where the BGM has 600 ha cleared .... additional clearing for the Hedges Gold Project increases mean flow salinity by 20%".

Apart from a discussion of the above quotations, further details are required regarding:

. lack of appropriate data with respect to long term salinity impacts.

. Potential risk of causing increased stream salinities to 34 Mile Brook.

. Estimation of salinity levels after de-commissioning and a commitment that they will not be significantly higher than current levels.

. The changed salt balance as a result of mining and water supply facilities.

. The impacts of saline water impounded in the water supply dam.

. The impact of a 10 fold salinity change on native vegetation.

. A target salinity of 5000 TSS in the tailings dam being used.

REVIEW OF SUBMISSIONS (contd)

Salinity information is based on only six bore holes. A more detailed evaluation is required.

4. JARRAH DIEBACK

The Hedges Gold Project is located in a Disease Risk Area. Further details and comments are required on the following:

. the likelihood of substantial dieback spread to adjacent native forest. It is claimed that normal dieback procedures have not been able to control the spread of dieback in bauxite mining operation.

. The environmental impacts of the project will be magnified many times through fire management and dieback.

. A construction programme to address drainage control, especially on the haul road alignment, which may precipitate the introduction of dieback after rainfall.

. Alcoa's capacity to ensure that contractors and personnel will consistently and effectively observe the environmental requirements required.

. To reduce the impact of dieback, the haul road should be lower in profile and a radius of curvature of 150 m. The road should stray out of the stream zone vegetation and should be built early so that all access can be along this route.

. The commitments to dieback control should be extended to following the same dieback planning and control mechanisms as those agreed for bauxite mining near Huntly.

5. SOCIAL AND ENVIRONMENTAL IMPACTS:

Most submissions were concerned that the Hedges project may have a major and deleterious impact on the native forest ecosystem in the eastern, low rainfall, high salinity and dieback risk areas of the Northern Jarrah Forests.

Alcoa need to comment on the following concerns:

. Loss of irreplaceable native forest of high conservation value.

. The impact on native flora and fauna.

. The combined effect of Hedges and BGM's open cut proposals.

. Potential loss of bauxite resources.

. Total land impact, including private land.

REVIEW OF SUBMISSIONS (contd)

## 6. INFRASTRUCTURE

The main concerns expressed in submissions were those of traffic and access. Further details are required with respect to:

- Generation of traffic in both the construction and operation phase. As the traffic on the Pinjarra-Williams Road west of the Bannister-Marradong Road and east of Dwellingup will increase by an estimated 50%, this cannot be said to be "minor". Heavy traffic may also be a problem particularly on the narrow 3.7 m wide seal east of Dwellingup and also on the climb up the scarp between Pinjarra and Dwellingup.

- The problems of an access which, at least in part, has been poorly maintained and for most of its length is too narrow, must be addressed. It is suggested that Alcoa make a significant contribution towards the cost of widening and reconstructing the Dwellingup-Boddington section of the Pinjarra Road.

- The hazards of transport of various chemicals. This should include quantities, modes of transport and proposed routes, including a proposal for a by-pass road around Dwellingup townsite for all commercial traffic travelling to the Hedges Gold Project Site.

- Access for fire control purposes - at least one controlled burn will be necessary.

The following suggestions should also be addressed:

- That access to the mine be option 1, page 13 of the ERMP.

- That the preferred power line route option is option 3 in the ERMP.

- That access to the plant site be via Boddington, Soldiers north, Siding Road and a road to be constructed along the boundary of Murray locations 530 and 703. This will avoid unnecessary disturbance to the existing environment and direct traffic through a controlled area.

- The proposed construction camp should be established in the Boddington area on suitable land made available.

The long term recreational potential of the area, including Bibbulmun track and the future recreational use of the Hedges water supply should be addressed.

## 7. BIOLOGICAL INFORMATION

There is a need to gather basic biological information (including streams to be affected), over several years.

Alcoa should conduct a baseline biological study for the project area. The results of this study should be reported to the State. There should be a commitment to adjust project management to take these into account.

REVIEW OF SUBMISSIONS (contd)

## 8. MINE PIT

Due to various reasons, the dimensions of the actual mine pit have not been defined.

Specific detail should be provided of details of the dimensions of the Hedges proposals. Details should include:

- Maximum pit depth, aerial scale, shape.
- Horizontal extent.
- A map of final pit dimensions.
- Better slope.
- Mining of ore bearing topsoil.
- Retention of "sufficient" topsoil - define "sufficient".
- Dimensions of waste and low grade ore dumps.
- On completion of mining operations the final pit levels and slopes should be graded to ensure that the entire mine site area drains into 34 Mile Brook or other natural water course. The pit area should be backfilled with waste ore, as in the BGM proposal.

## 9. HAZARDOUS CHEMICALS

Details should be given of:

- Cyanide storage.
- Protection of personnel, especially from toxic vapours.
- The mist elimination system of HCl fume control.

It is suggested that mechanical mixing is to be preferred over air agitation as less hydrogen cyanide is released to the atmosphere.

## 10. AIR POLLUTION

It has not been established that air pollution is a minor factor. No data is given to detailed temperature, rainfall, wind and other climatic parameters that are absolutely essential components to understanding air pollution aspects. Details are required of atmospheric conditions on wind direction, speeds, temperature, rainfall, seasonal and diurnal variations.

Potential air, terrestrial and water pollution problems arising from the project should also be addressed.

REVIEW OF SUBMISSIONS (contd)

## 11. JOINT VENTURE

Discussion between Alcoa and Worsley on joint development of the Hedges ore body failed because of commercial rather than environmental considerations.

The Alcoa preferred (private land) option for the Hedges development could involve State Forest and private land impacts that are twice and four times, respectively, those of an Alcoa/Worsley joint venture.

Alcoa should attempt to reach agreement with Worsley on the mine site development of a joint venture with the already established BGM. Existing mine treatment and storage facilities could be shared without a 50/50 sharing of the Hedges ore body.

## 12. REHABILITATION

Rehabilitation concerns mainly centred around the long term management of impacts after the decommissioning of the Hedges operation and details of rehabilitation.

Further details are required of:

- Rehabilitation, given that techniques for rehabilitating at Hedges will be substantially different than for bauxite mining. These details should show the shape of the landscape and the anticipated rehabilitation techniques to be used on the disturbed areas, especially the backfill in the pit.

- Types of trees to be re-planted. Will the plantation be "self sustaining", or will it require fertilisation, thinning, re-planting and fire control?

- Proposed timetable for rehabilitation, given that stored topsoil will biologically degrade.

- Mining proposals for topsoil - the top 10 cm should not be mined.

- Stockpile locations, with respect to their proximity to wetland areas adjacent to 34 Mile Brook.

APPENDIX 2

ALCOA OF AUSTRALIA LIMITED RESPONSE TO SUBMISSIONS

APPENDIX 2

ALCOA OF AUSTRALIA LIMITED
Incorporated in Victoria

Cnr. Davy and Marmion Streets, Booragoon, Western Australia 6154

ALCOA
AUSTRALIA

17th December 1987
OGN/EL

Chairman
Environmental Protection Authority
BP House
1 Mount Street
PERTH WA 6000

Attention: Mr Michael Waite

Dear Sir,

HEDGES GOLD PROJECT - RESPONSE TO PUBLIC SUBMISSIONS

As required by the Environmental Protection Authority, Alcoa has made the Hedges Gold Project ERMP available for public comment for a period of 8 weeks, ending 4th December 1987. During that period, a total of 196 copies of the ERMP were distributed.

The resulting public submissions have been summarised and a copy of the summary made available to Alcoa. The Company's response to those submissions is attached.

We would be pleased to discuss any environmental aspects of the project with the Environmental Protection Authority if required.

Yours faithfully,

R.A.G. VINES
Executive Director

OGN06/87/1171

# HEDGES GOLD PROJECT ERMP

## COMPANY RESPONSE TO PUBLIC SUBMISSIONS

### 1. TAILINGS DISPOSAL - SITE CONDITIONS, DESIGN ISSUES

Since submission of the ERMP Alcoa, has carried out detailed site investigations, laboratory testing, and detailed design of the tailings disposal system. These are reported in a detailed design submission which has been forwarded to the Government for approval as required under the EPA Act (1986) and the Referrable Dam provisions of the Rights in Water and Irrigation Act, 1978 (and amendments).

During the design period, discussions on various technical matters have taken place between engineers from Alcoa, the design consultants and Government Departments.

Alcoa believe that the approach taken and the discussions which will proceed formal design approval will result in high security tailings facilities which will pose minimal environmental risk.

Effectiveness of Containment System :

Alcoa believes that the containment and recovery systems proposed will be effective. Site characteristics, including foundation conditions and available dam construction materials are favourable and combined with the underdrainage system proposed should ensure that seepage losses are minimised. Foundation soils and basement rocks can vary considerably within the Darling Range; however the granite-dolerite profiles identified in the tailings dam area consistently demonstrated low natural permeabilities and should be more predictable than in the adjacent "Greenstone" belt.

Alcoa does not believe that additional measures to control seepage from the tailings pond are warranted, for the reasons outlined :

(1) The tailings pond is an integral part of the gold processing plant. Treatment of tailings to remove cyanide would affect the process economics and may affect the ability to recycle water from the tailings dam. Nevertheless, methods of treating tailings or recovered water to remove cyanide, such as the Golconda process, will be studied for their possible application.

(2) The tailings impoundment soils and underlying geology are such that additional sealing blankets over the base are not justified. The underdrain system will effectively reduce the hydraulic head over much of the base area and thereby reduce seepage losses.

(3) Soil conditions beneath the dam wall, which have been investigated in much more detail since the ERMP was written, are such that additional cut off provisions are not warranted. Depth to rock is 20-50m so slurry cut off walls and grout curtains would be prohibitively expensive and difficult to construct. In addition, Alcoa's experiences with soil grouting indicates that this is not a reliable method of sealing soils against seepage.

Alcoa believes that its tailings system design offers at least as much security as that constructed by BGM. It is sited outside of any future public water supply catchments with the Hotham River (already considered too saline for human consumption) as its primary receiving water body. This location diminishes the risk to public water supplies and other downstream users.

Alcoa believes that the Hedges tailings dam is located in an area with a thinner layer of highly weathered and high permeability soil at the surface and far less variability in the foundation rock and weathered rock zone, than is likely in the adjacent "Greenstone" belt.

Alcoa's design includes a more comprehensive underdrain system which will intercept leachate and relieve hydraulic pressure on the floor of the valley upstream of the embankment. A surficial seepage interception and containment system downstream is also proposed. Detailed evaluation of the appropriateness of any additional design requirements will be determined in consultation with the Water Authority through the works approval process.

Alcoa is prepared to make a commitment to construct more positive cut off features or seepage collection systems if unacceptable seepage occurs. The proposed method of downstream dam construction does however allow these methods to be instituted later if monitoring indicates unacceptably high levels of seepage beneath the first stage embankment.

Tailings Properties :

The tailings dam has been designed as a "water retaining" structure and as such does not depend upon the tailings strength or permeability properties to achieve the required performance. The design of the underdrainage system does require data on tailings particle sizing and permeability. We do not believe that these data can be obtained "synthetically" prior to start up as they depend upon the exact ore characteristics, grinding and other processing steps and tailings deposition techniques practised. Design data have been based upon published information and Alcoa's experiences with red mud.

Disposal Technique :

The rationale for choosing the tailings disposal method is discussed in the ERMP and further in the Design Report. The expected settling and beaching characteristics of the gold tailings (compared to red mud) should allow the disposal area to be run in a largely "dry" mode with a minimum liquor pond. Alcoa have also considered the possibility of flocculant addition to the tailings at the point of discharge to further improve beaching and reduce segregation of fines thereby increasing the "dry" area and reducing the decant pond size. This technique has been applied successfully on red mud at Alcoa's Pinjarra refinery. It can be readily added on to the process at a later date and will be assessed for application at Hedges following start-up.

The final average tailings density with this form of disposal will be slightly lower than that which would be achieved with a pre-thickened tailings technique due to lower solar drying efficiency during deposition; however other features such as strength and drainage of the deposit and final rehabilitation of the surface will be similar. Under these circumstances and particularly considering the project duration and final size of the tailings area the additional, capital and operating costs involved in dewatering the tailings prior to discharge into the tailings area are not justified.

Underdrain System - Design and Operation :

Design of the underdrain system is covered in the design report.

During the initial stages of filling there may be a relatively deep decant pool and a thin layer of fine tailings over parts of the underdrain system. By operating the system in this hydrostatic condition the risk of scouring fine tailings into the underdrain system which could result in clogging is increased. It is therefore preferred to keep the system closed until a deeper tailings layer has developed and the decant pond head has decreased to more normal operating levels.

To counter the concern about initial migration of tailings water into the foundation zone, it is planned to flood the base of the impoundment area with fresh water several months prior to start-up to saturate the foundation soils. This should reduce the likelihood of high initial uptake of contaminated water and therefore the development of seepage problems during the early operating period.

Dam Wall Design :

Alcoa's experiences with tailings dam slopes suggests that a 1:2 slope can be stabilized to avoid long term erosion by the proper establishment of a vegetation cover and adequate attention to drainage diversion at the crest. After construction of the final embankment the downstream slope will be stabilized by placement of a topsoil layer and then revegetated. As an alternative the placement of gravel bedding then lateritic caprock layer could be considered. Flattening of the slope to 1:4 as suggested should be avoided as the slope catchment area will double and monitoring, toe drainage and underdrain sump facilities would have to be relocated a further 90 m downstream to keep clear of the toe.

Hydrological Assessment of Tailings Dam :

A complete hydrologic assessment has been carried out and is reported in the Design Report which has been submitted to Government for approval.

The initial tailings dam and its extensions have been designed to store runoff from a wet year with a 1:1000 year frequency.

The likely effects of catastrophic failure of the tailings dam are also discussed in the Design Report.

Leachate - Soil Interactions :

Alcoa will carry out or sponsor studies on the interactions between tailings leachate and foundation soils after the commencement of operations when the tailings and leachate properties can be determined. The Government Chemical Laboratories have recently proposed a study on this topic and Alcoa has indicated a willingness to be involved in and help fund the project.

TAILINGS DISPOSAL - WATER QUALITY ISSUES

Estimates of downstream water quality impacts are made in the detailed Design Report. These are however highly subjective due to the assumptions which must be made in the calculations. Water quality changes will be carefully monitored prior to and following start-up and if adverse trends develop then measures will be taken to protect downstream users, in this case the Worsley Timber Company. One of these measures could be the construction of a catchment dam and pump back facility downstream of the tailings dam. However, its location and design would best be determined following hydrogeological monitoring and investigations after start up.

In the event that unacceptable water pollution occurs downstream, Alcoa shall carry out remedial action to the satisfaction of the Government.

Alcoa do not believe that further theoretical modelling of possible increases in salinity and cyanide concentration in the Hotham River are warranted at this time due to the complex interactions that are possible. Future studies and monitoring will allow more accurate predictions. If levels are predicted to exceed acceptable limits then strategies for dealing with the problem at its source, such as collection and treatment of seepage water will be developed.

Discharge Water Quality Criteria :

Process make-up water will be drawn from the Hotham River during the winter months when salinities can be in the range 1000 - 9000 mg/l. It seems unrealistic therefore to propose a standard which is higher than the levels in the receiving water.

During the operating period deliberate release of water from the tailings dam will not occur. Any seepage originating from the deposit is likely to have a salinity above input process water levels due to the salts added during the process, the concentration effects of evaporation in the tailings pond and mobilization of salts from the soil profile. During the rehabilitation phase release of runoff water and drainage will be necessary. Effluent limits should therefore reflect the assimilative capacity of the receiving water or its ability to accept effluents without impairing the beneficial uses. This approach will allow greater flexibility in achieving rehabilitation goals.

Cyanide limits should likewise be set to reflect the assimilative capacity of the receiving water body and also the practical realities of sampling and analysis. Alcoa will carry out or assist with research and studies into cyanide as they relate to the Hedges Project.

Groundwater Monitoring :

The hydrogeological monitoring and assessment programme will be commenced prior to start-up and will be updated continuously, utilising Alcoa's hydrogeological expertise and consultants if required. Reporting frequency and any special requirements will be covered under the effluent licencing procedures.

Monitoring of background groundwater quality from bores established during the investigation programme has already commenced. The long term monitoring layout is covered in the design report and consists of bores downstream of the final dam as well as bores drilled from the crest of each stage of the dam giving an average bore spacing of around 50 m. Additional bores in the dam shoulders and the saddle on the southern flank of the valley are also included.

Tailings Dam Water Balance :

The water and salt balances for the tailings circuit will be monitored as an important part of the process plant control procedures. In our experience this approach is unlikely to provide meaningful data on seepage losses due to the range of variables involved and the inability to measure these variables with high enough accuracy.

Recovery Bore Installations :

Subsurface investigations at the Hedges tailings dam site reveal foundation soils with consistently low permeabilities. Ground water movement through these soils should be very slow unless more permeable pathways beneath the dam exist. If such zones are detected during the installation of the comprehensive monitoring bore network they will be carefully defined and monitored during initial flooding of the base of the dam with fresh water prior to start-up. If a rapid hydraulic response occurs then grouting or installation of recovery bores will be considered.

If movement of polluted ground water in the foundation zone is detected in the primary monitoring bores on the dam centreline then a detailed investigation will be carried out to enable optimum design and location of recovery bores. If necessary a properly designed recovery system could be installed and commissioned within 2-3 months which should be adequate to ensure containment of seepage.

TAILINGS DISPOSAL - REHABILITATION ISSUES

Neutralization of Toxicity :

The biological toxicity of the tailings deposit is related to its alkalinity, salinity, and in particular, cyanide content. There are no known post placement techniques for amendment of whole tailings deposits to remove this toxicity. The surface material can be leached and neutralised by chemical or organic amendments to allow vegetation growth and rainfall shedding without undue toxicity problems. Leachates may be collected and treated to reduce toxicity prior to discharge.

Detailed Management Prescriptions :

Long term management issues have been identified and broad commitments made to management within guidelines that are acceptable to the authorities and the private landowner. Alcoa do not believe it is appropriate to spell out detailed prescriptions until comprehensive data are available. For example, the final vegetation cover cannot be selected until sufficient data are available on soil physical and chemical characteristics. Condition monitoring prior to and during the operating period will provide the base data necessary to develop management prescriptions. Research and progressive trials and implementation during the operating phase and immediately following closure will establish the optimum final management techniques.

2. HYDROLOGICAL

Mining Operations :

To minimise sediment discharges from the operations it is proposed to use a combination of surge sumps and settling ponds. Figure 6 of the ERMP shows the probable locations and sizes of the sumps and ponds for handling runoff from the minepit and associated stockpiles. These structures have been sized to settle 5 um particles during a storm with a recurrence interval of once in 50 years. For the haul and access roads the surge sump and settling pond systems will be sized to settle 30 um particles during at least a once in 20 year storm. Storm runoff from the plant site will be channelled into the tailings dam.

The minepit and associated haul road will have some effect on the water quality of 34 Mile Brook during the life of the operation. The extent of this effect is expected to be minor and is described in the ERMP. It is expected that once rehabilitation of these areas is completed the turbid surface runoff will rapidly reduce to a negligible level. As an example of the extent of sediment yield reduction that will occur after rehabilitation, data were obtained from a bauxite minepit near Dwellingup. During the first year after rehabilitation 260 kg/ha of

sediment entered the discharge system. This rapidly declined to 2 kg/ha within four years. It should be noted that this particular mine pit was an extreme water shedding site and sediment loads at Hedges are expected to be lower. In fact it is highly likely that given the rainfall regime of the Hedges area, plus the expected revegetation densities, that no measurable sediment yields will emanate from the rehabilitated areas once the vegetation has become established.

To prevent water handling problems during mining of the stream zone orebody, it is planned to mine it only during the summer months. The stream is perennial. Once mining has been completed in the stream zone it is planned to rehabilitate this part of the pit immediately. Wetlands would be one option considered. A stabilised overflow will be established on or near the southern clearing boundary and it will probably have an invert level of 237.5 m AHD. This will produce a pond of approximately 6 ha, and could produce a useful wetland suitable for waterfowl.

With regard to monitoring of water quality and quantity of 34 Mile Brook, Alcoa agrees to co-ordinate its monitoring with that of BGM and the Water Authority of W.A. requirements.

Domestic waste disposal within the 34 Mile Brook water supply reservoir catchment will use self-contained toilets and enclosed garage bins. Once the mining operation has commenced it is expected that the majority of workers will use facilities at the plant site.

Water Storage Dam :

Design Details :

A detailed design report including site geology and hydrogeology data has been submitted to the WAWA for approval.

Hotham River :

Studies of the available WAWA data show that adequate water should be available from the Hotham River for both the BGM and Hedges Projects at the proposed licence amounts, while maintaining the minimum flow

requirement. So long as both companies maintain their withdrawal rates within their licences then no conflict should occur.

Alcoa will establish a correlation between the minimum flow at the Marradong Gauging Weir and the river level at the pump suction. An automatic cutoff system will ensure that pumping ceases at this time.

Details of Pumping Installation :

Details of the pumping installation have been submitted to the Water Authority for approval with the withdrawal licence application.

Effect on Stream Vegetation :

The water storage dam is located on a cleared paddock with only minimal vegetation remaining along the stream, the effects of the dam on vegetation will be minor.

Streamside vegetation which will be inundated by the dam will be removed. Valley floor vegetation upstream of the impoundment should not be affected. The natural ground water seepage flows within the cleared valley are already quite saline (3000 ppm) so the increases which may be expected after construction of the water storage dam should not adversely affect existing native vegetation. Downstream of the proposed dam natural seepage will continue to sustain the remaining streamside vegetation.

Impact of Saline Water in Water Supply Dam :

The proposed water supply dam for the Hedges project is located in the headwaters of a stream which is already extensively cleared for agriculture. Salinities in this stream reach similar levels to those of the winter flows in the Hotham River. Storage of Hotham River water in the water supply dam over the life of the project is therefore not expected to have a significant effect on either the salinity or downstream ecology of the stream on which the dam will be sited.

Future Use of Water Storage Dam :

The water supply system will become the property of the landowner when Alcoa's operations cease. The dam can be drained and refilled with lower salinity water from the Hotham River during wet periods, 1000-2000 ppm T.S.S., and replenished with natural runoff from Long Gully Brook. Its future use at this stage has not been determined.

## 3. SALINITY

Wagerup ERMP Commitment - Impact on Water Resources :

Alcoa's proposal to conduct a limited gold mining operation in the Hotham River catchment is not a violation of the environmental management commitments made in its 1978 Wagerup Alumina Project ERMP. The commitments in question refer specifically to Alcoa's bauxite mining operations in Mineral Lease 1SA. The potential impact on water resources of large-scale, long-term bauxite mining operations in the lower rainfall area is presently uncertain. Alcoa's commitment to defer full-scale bauxite operations in lower rainfall areas, pending the outcome of research, reflects this fact.

The Hedges Gold Project area will not lie within Alcoa's Mineral Lease 1SA and conditions associated with operations within that lease do not apply to the proposed gold mine. The project should therefore be assessed on its own merits under the provisions of the Environmental Protection Act.

By way of comparison, the total amount of forest clearing for the whole life of the proposed Hedges Gold project represent less than the amount of clearing required for one years bauxite production. Further, the clearing will be entirely within the Hotham River catchment, which is already too saline for development as a public water supply due to extensive clearing for agriculture.

The existing BGM water supply reservoir is located on 34 Mile Brook, an ephemeral freshwater tributary of the Hotham River. The reservoir relies on inputs of brackish water pumped from the Hotham River for its

viability as a water supply for the BGM operations. When its low net water yield is considered in relation to the costs of the pipework and pumping facilities required to transfer the water to local townships or other reservoirs, the potential of 34 Mile Brook as a public water supply must be considered marginal. If developed, its contribution to the region's water resources would be very small. In the context of an impact on regional water resources, an incremental increase of 20% in the salinity of 34 Mile Brook would be inconsequential.

Estimation of Salinity Levels :

The assessment of salinity increases used in both the Boddington Gold Mine ERMP and the Hedges Gold Project ERMP, was based on the very conservative assumption that additional groundwater recharge following mining would be similar to that which occurs following permanent clearing for agriculture.

A key objective of the Hedges minesite rehabilitation program will be to re-establish indigenous vegetation wherever possible. It is well known from research that deep-rooted native vegetation has a substantially greater capacity to extract moisture from the soil profile than agricultural crops or pastures. Consequently, groundwater recharge beneath the rehabilitated minesite is expected to decline to levels much closer to that beneath that native forest than exists beneath areas permanently cleared for agriculture.

Any incremental increase in the salinity of 34 Mile Brook as a consequence of the Hedges project is therefore expected to be relatively small and transient. It is not possible to state categorically that the increase will be insignificant in relation to pre-BGM salinities in 34 Mile Brook but it will be insignificant given that the BGM project has been approved and is in operation.

Alcoa recognizes that the actual impact will be strongly related to the effectiveness with which appropriate vegetation communities can be re-established on the minepit and haul road, and to a lesser extent on the minepit's final topography and drainage characteristics. The Company reiterates its commitment to consult closely with relevant Government agencies in the development of the rehabilitation and drainage program, and reach agreement with them on its final design.

Effect of Salinity Increases on Native Vegetation :

The Hedges project will not result in a 10 fold increase in the salinity of streamflow in 34 Mile Brook. It could result in an incremental increase of up to 20% on the estimated salinity levels for the existing BGM project. However, it should be emphasised that these increases are based on very conservative assumptions (refer to section on "Estimation of Salinity Levels"); they should be considered maximum figures, and actual salinity levels are expected to be much lower than those estimated.

It is considered unlikely that the predicted incremental salinity increase will have a significant additional impact on the stream zone vegetation. This vegetation will be carefully monitored during the life of the operation and until vegetation is well established on the rehabilitated minepit. However, it will be difficult to ascertain whether observed changes (if any) are a consequence of the incremental impact of the Hedges project, or would have occurred as a result of the BGM project alone. All vegetation communities involved are relatively well represented in conservation reserves.

Borehole Salinity Information :

Although only 6 boreholes from the minesite have been analysed so far, this is in fact a reasonable number of holes for the relatively small area involved. Furthermore, the results from these holes are entirely consistent with those expected given that the Hedges orebody is simply an extension of the BGM orebody, occurs on the same ridge and is in the same geological environment. However, twelve of the deep reverse circulation boreholes planned for the initial stage of mined development will be sampled and analysed for salt content.

## 4. DIEBACK

Control of Dieback Spread :

Alcoa will meet the requirements of the 7 way test for access into D.R.A. The dieback management prescription developed for bauxite mining, where applicable, will be adapted for use at Hedges.

The Hedges gold mining project will be monitored for its impact in terms of dieback spread downslope, dieback intensification and the suitability of the mined out area for returning dieback susceptible species. The impact on downslope forest will be minimised by adequate drainage control, as will intensification of the disease. Because of the location of the orebody on a ridge which is enclosed by a loop of 34 Mile Brook, and through careful siting of the haul road, the potential area of forest placed at risk is quite small.

The alignment for the haul road which connects the minesite and the processing plant will be agreed with CALM, taking full account of dieback and safety factors. The construction of the road will fulfil the requirements of the 7 way test.

Contractors :

All contractors who will be involved in the Hedges Gold project will be required to read and understand an environmental control document which they will sign. This document will outline the environmental controls within the operation, such as dieback and drainage controls and the consequences of improper action. An environmental scientist has been appointed to oversee the necessary policing of the contractor. This person will liaise with CALM, the Water Authority and Alcoa environmental specialists in determining appropriate methods of environmental control.

## 5. • SOCIAL AND ENVIRONMENTAL IMPACTS

The total area of State Forest affected by the Hedges project is small, around 150 ha. It is not correct to infer that the affected area has high conservation value; it is not situated in or immediately adjacent to any conservation reserve, and no plant or annual species or communities are threatened by the project. Rehabilitation following project completion, as described in the ERMP, will further reduce the effects of the project on the forest ecosystems.

The potential loss of bauxite resources is currently being addressed in discussions with State Government authorities. However, the amount or ore lost will be inconsequential in relation to the total bauxite reserve.

The total land cleared for the project will be approximately 320 ha. Impacts of the project on native forest have been significantly reduced by siting the plant, tailings dam and water supply dam on private land which is either heavily logged or already cleared.

The combined effects of the Hedges and BGM projects have been addressed in the ERMP. The BGM project underwent detailed environmental impact assessment, and the Hedges project represents a small incremental increase in terms of areas affected. Issues such as likely increases in salinity, and effects on conservation values are addressed in detailed in the ERMP.

With regard to the social environment, any impacts need to be balanced against the significant economic benefits which will be gained through employment and purchase of goods and services.

## 6. INFRASTRUCTURE

Alcoa is currently undertaking discussions with Local and State Government authorities regarding the status of the Dwellingup/Boddington road.

Chemicals will be transported according to standard Government safety requirements.

Access to the plant site, and location of construction camps are currently being discussed with Boddington Shire. Access for fire control purposes will be provided.

The long term recreation potential of the area will be considered jointly with State and Local Government authorities, as rehabilitation plans are developed.

## 7. BIOLOGICAL INFORMATION

Alcoa has commissioned detailed consulting reports on the flora and fauna of the Hedges project area. As well as this, Worsley Alumina Pty.

Ltd. has conducted detailed biological studies in and adjacent to the nearby Boddington Gold Mine project area.

Alcoa considers that given this detailed information, there is little merit in conducting detailed studies over several years for a project with a life span of only 5-6 years. Sufficient information is already available to adequately assess the project's likely environmental impacts.

Any effects on flora and fauna will be reduced by :

- monitoring and (if necessary) taking steps to reduce waterfowl landings on the tailings dam,
- monitoring stream zone vegetation, as described in section 3, "Effects of Salinity Increases on Native Vegetation",
- monitoring stream water quality,
- taking steps to minimise dieback spread, and
- site rehabilitation.

## 8. MINE PIT

Mine Pit Area :

The area outline of the pit is not likely to change significantly from that outlined in Figure 5 (ERMP). If any future orebodies were to be located outside the immediate orebody lease, Alcoa would undertake required environmental assessment procedures before any mining could commence.

Pit depth and shape :

The 50 metre drilling grid was carried out by tractor mounted vacuum drilling rigs. These rigs were limited drilling depth, and less than 25% of the total holes drilled reached basement. There are also a number of holes which ended in high grade ore without reaching basement. Hence it is not possible at this stage to accurately state final pit depths. This information will be available when the 25 metre grid drilling is completed. This drilling will be carried out by reverse circulation rigs which are capable of drilling to basement.

The weathered zone above the basement is up to 80 metres thick in some areas and there are indications that mineralization extends down to the basement.

Two diamond drillholes have been drilled into the basement, and the results indicate that there is some mineralization present. Further exploration of the basement rock may demonstrate economically extractable ore reserves. If this occurs, as stated in the ERMP, detailed mining plans will be submitted to the Government for approval.

With the above information it can be seen why it was not possible to give precise commitments on final pit depths and slopes. Wherever practicable, slopes will be reshaped to gradients equal to or less than those occurring naturally in the immediate orebody area (20-25%). Where steeper slopes remain, steps will be taken to ensure long term slope stability and public safety. At all stages, extensive liaison with the State will take place to ensure that the best practicable reshaping and stabilising (including revegetation) techniques are used.

Topsoil :

Alcoa's research results indicate that returning 5 cm of topsoil provide adequate nutrient and seed material for acceptable rehabilitation. Sufficient topsoil will be returned to ensure that a minimum of 5 cm topsoil layer can be applied to all rehabilitated areas.

Waste :

In-pit deposition of any waste will not be possible until the drilling programme is completed, and a decision is made on whether mining will extend into bedrock. As stated in the ERMP, the waste material is expected to total 1.5 $Mm^3$. The extent to which it will be practicable to return this to the pit will not be known until more detailed mine planning has been completed. However, the figure of 1.5 $Mm^3$ should be considered a maximum stockpile size. Wherever practicable, waste will be returned to mined-out areas of the pit.

The remaining waste stockpile will be reshaped to ensure that slopes are within those naturally occurring in the area (20 - 25%). Drainage, topsoil return and revegetation will all be carefully designed in conjunction with State Government authorities, to ensure stability and conformity with the surrounding landscape. Preliminary landform analysis indicates that the stockpile can be effectively blended into the landscape.

Low Grade Ore :

In the ERMP, it was stated that a low grade ore stockpile of 1.9 $Mm^3$ would be sited near the waste stockpile. The low grade ore would be processed after the high grade ore processing was completed, depending on gold prices at the time.

If the ore is processed, the low grade ore stockpile near the mine pit will be removed and the site rehabilitated. If it is not processed at all, the stockpile will be landscaped in the same manner as the waste stockpile. In the latter case some of the material may be returned to areas of the minepit to enhance rehabilitation.

## 9. HAZARDOUS CHEMICALS

Handling and storage of hazardous chemicals will conform to stringent safety requirements and all Government regulations. These are outlined in the ERMP.

## 10. AIR POLLUTION

Emission of atmospheric pollutants will be regulated, through licensing, to ensure compliance with the Environmental Protection Act (1986). Detailed climatic studies were not considered necessary because the potential for air pollution problems occurring are minimal. The use of LPG will eliminate possible $SO_2$ pollution, whilst mist eliminators will control the emission of any hazardous fumes used in the gold extraction process.

## 11. JOINT VENTURE

As stated in the ERMP, a joint venture between Alcoa and Worsley Alumina Joint Venture has not proved possible due to commercial reasons.

The information available to Alcoa suggests that the differences between the potential environmental impacts of joint development and Alcoa's preferred option are small. It is not correct to state that State Forest impacts of joint development would be half those of the preferred option, which is 150 ha. The mine pit alone, with necessary clearing, is 100 ha. Areas of waste and low grade ore stockpiles quoted in the ERMP (32 ha) should be considered maximum figures and may be much lower. Alcoa was advised by WAJV that a second tailings dam would be required under a joint venture project. The impact of the extra water supply on state forest could possibly be avoided if a second dam were constructed on cleared private property.

Whatever the case, the area differences between the two developments are considered to be insignificant compared to the total area of State Jarrah Forest (approximately 1.4 million ha.) and the total area of any vegetation types affected.

A proposal to treat (with toll payment) Alcoa ore through expanded BGM facilities was suggested but rejected by the Worsley Alumina Joint Venturers. Under such an agreement, the existing treatment and storage facilities (including the tailings dam) would have been used to maximal advantage.

## 12. REHABILITATION

As discussed in section 8: Mine Pit, and in the ERMP, it is not possible to give precise details of rehabilitation techniques without knowing the final pit configuration. Slopes, pit depths, drainage characteristics and soil physical and chemical parameters will all determine the final rehabilitation techniques used. With Alcoa's extensive experience in mining rehabilitation, and information from other industry sources, rehabilitation techniques are not expected to pose any insurmountable

problems. Extensive discussions will take place between Alcoa and State Government authorities, and agreement obtained on the most appropriate rehabilitation methods. These methods will include details of topsoil handling procedures, and rehabilitation monitoring and management.

Mining proposals for topsoil, and details of stockpiles are discussed in section 8 : Mine Pit.

## GENERAL CONCLUSIONS

Most of the issues raised in the submissions concerned tailings storage and hydrology. Many of these issues were related to the fact that detailed site investigations and design work were only in the preliminary stages when the ERMP was prepared. Since that time, detailed site investigations have been carried out and a Design Report submitted to the Government for approval. Studies have shown that the site is suitable for construction and efficient performance of the tailings reservoir.

Other issues, such as the pumping requirement from the Hotham River, and the design of the water supply reservoir are likewise being dealt with through Government licensing and approvals procedures. This ongoing liaison will ensure that all relevant tailings and water supply issues raised in submissions are satisfactorily resolved.

Currently, discussions are taking place with CALM on the question of dieback management. Drilling programmes, haul road alignment and mining operations will all be subjected to the 7 way test and modified where necessary. Implementation of effective procedures to minimise spread of dieback, together with stringent controls on contractors will result in very little of the 80 ha of forest considered potentially at risk being affected.

Other issues raised in the submissions are either being investigated through further studies, or discussed with State and Local Government authorities. At all stages, extensive liaison with these authorities will take place to ensure that not only are environmental regulations met or exceeded, but that a high standard of environmental management is achieved.

With the satisfactory resolution of issues raised in submissions, Alcoa is confident that the Hedges Gold Project can proceed without posing unacceptable risks to the environment.

APPENDIX 3

STREAM FLOW DATA

## 614224 HOTHAM RIVER MARRADONG ROAD BRIDGE

| | |
|---|---|
| River Basin | Murray River |
| Location | Latitude S 32° 52' 00" AMG. Grid N 6363300<br>Longitude E 116° 23' 47" E 50 443550 |

### CATCHMENT CHARACTERISTICS

| | |
|---|---|
| Catchment Area | 4020 km² |
| Climate Zone | Mediterranean climate, medium to low winter rainfall. |
| Average Rainfall | 590 mm/annum (Range 1000-450) |
| Pan Evaporation | 1600 mm/annum (Range 1800-1500) |
| Geomorphology | Generally low relief; undulating plateau, partially dissected, lateritic soils over Archean Granitic and metamorphic rocks. |
| Landforms | Map Units; Atlas of Natural Resources Darling System WA (Ref 4)<br>15% — Dwellingup Laterite Plateau; uplands, duricrust, gravels and sands over mottled clay soils.<br>15% — Pindalup/Coolakin Upland Valleys; sandy, gravelly slopes, some rock outcrops, narrow valley floor.<br>55% — Michibin Dissected Laterites; gentle slopes, yellow duplex soils and red earths some rock.<br>5% — Rocky Areas Outcrops; moderate slopes, shallow red earths, much rock outcrop.<br>10% — Williams Alluvial Valleys; valley floors of yellow duplex soils and wide sandy terraces. |
| Natural Vegetation | Map Units; Vegetation Survey of WA (Ref 1)<br>25% — eMc Forest; jarrah-marri forest on lateritic uplands in lower catchment.<br>25% — eMi Woodland; marri-wandoo woodland, some jarrah, in upland valleys.<br>15% — eMi Woodland; wandoo-mallet woodlands on lateritic residuals in upper catchment.<br>35% — eMi Woodland; wandoo-York gum woodlands on dissected laterites in upper catchment. |
| Clearing | Roughly 85% cleared, early clearing along valleys, broad acre clearing after 1950's. |
| Landuse | Small area State Forest and Conservation reserves, some private timber concessions, cleared areas used for sheep and cattle grazing and some cereal production. |
| Regulation | None apart from small farm dams on minor waterways. |

### GAUGING STATION DETAILS

| | |
|---|---|
| Period of Record | June 1966 to date. |
| Establishment | Hydrologic Network — Primary Mainstream Catchment. |
| Gauging Installation | Float operated continuous L&S graphical recorder to date. Debris and vegetation low flow control combining with channel control for medium flows to April 1975. Narrow crested V weir low flow control with channel for medium flow control, from April 1975. Bridge control for high flows for all record. |
| Stage Record | 98.9% recorded, 0.6% faulty. |
| Rating Curve | Poor early rating due to unstable channel conditions. Curve based on measurements to 151.8 m³/s which cover 95% of early recorded flow yield, and theoretical beyond. From April 1975 rating is good for full range; numerous measurements to 179.6 m³/s cover 98% of total recorded flow yield. |
| Sensitivity Measure | 99% of flow <1; 100% of flow <2. |
| METEOROLOGICAL NETWORK | Fair coverage, uneven distribution, 4 pluviographs, 3 storage, 8 daily read. |
| WATER QUALITY | Saline; long term average TSS value of 3400 mg/L. Water is hard. Trend to increasing salinity through time. Automatic Pumping Sampler in operation from July 1975 to March 1981. |
| FLOW DURATION | See flow pages opposite |

# APPENDIX 3

614224

MONTHLY FLOW - MILLIONS OF CUBIC METRES (AND DAYS MISSING FROM RECORD)

| YEAR | JAN | FEB | MARCH | APRIL | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | NA | NA | NA | NA | NA | 3.30# (14) | 51.1* | 21.0 | 16.0 | 3.53 | .80 | .19 | 95.8# (165) |
| 1967 | .10 | .00 | 0 | .05 | 7.03 | 104 | 105 | 45.5 | 15.5 | 2.40 | .61 | .15 | 280 |
| 1968 | .09 | .07 | .13# (19) | 1.17 | 2.76 | 38.5 | 44.2 | 42.8 | 23.0 | 4.96 | 1.15 | .15 | 159# 19) |
| 1969 | .05 | .02 | .06 | .14 | .28 | 2.94 | 7.58 | 6.01 | 1.49 | .64 | .14 | .02 | 19.4 |
| 1970 | 0 | .33 | .02 | .00 | .14 | 56.1 | 23.6 | 8.81 | 6.59 | 8.81 | .92 | .09 | 105 |
| 1971 | .02 | .07 | .15 | 1.23 | 1.26 | 3.37 | 4.82 | 10.6 | 7.64 | 9.22 | 1.02 | .54 | 40.0 |
| 1972 | .03 | 0 | 0 | 0 | .06 | .63 | 8.68 | 27.9 | 7.43 | 1.33 | .23 | .05 | 46.3 |
| 1973 | .00 | 0 | 0 | .04 | .22 | 9.62 | 38.0 | 57.8 | 27.0 | 6.27 | 1.13 | .11 | 140 |
| 1974 | .02 | .01 | .01 | .16 | 10.7 | 30.0 | 128 | 140 | 9.74 | 5.04 | 1.52 | .34 | 325 |
| 1975 | .05 | .02# (4) | NR | .17# (7) | 1.77 | 5.04 | 25.3 | 41.1 | 8.56 | 3.37 | .73 | .14 | 86.3# 42) |
| 1976 | .11 | .05 | 1.17 | .72 | .95 | 1.70 | 2.59 | 16.3 | 5.77 | 2.60 | .57 | .14 | 32.7 |
| 1977 | .02 | .01 | .01 | .04 | .18 | 1.18 | 2.23 | 12.5 | 2.58 | 2.10 | 2.52 | .12 | 23.5 |
| 1978 | .03 | .02 | .01 | .02 | .44 | 6.52 | 86.0 | 17.4 | 6.71 | 5.50 | .44 | .12 | 123 |
| 1979 | .44 | .05 | .03 | .07* | .21 | 1.44 | 5.59 | 5.19 | 2.37 | 1.04 | .41 | .07 | 16.9* |
| 1980 | .01 | .03 | .02 | .25 | 1.01 | 4.28 | 9.54 | 9.60 | 4.37 | 3.38 | .88 | .13 | 33.5 |
| 1981 | .92* | .05 | .16 | .54 | 1.92 | 25.4 | 37.3E | 65.1E | 8.78 | 2.62 | 1.41 | .36 | 145E |
| 1982 | 34.4 | 1.47 | .30 | .27 | .53 | 3.73 | 5.74* | 9.92 | 7.66 | 3.86 | .58 | .57 | 69.0* |
| MEDIAN | .04 | .03 | .02 | .14 | .74 | 4.66 | 23.6 | 17.4 | 7.64 | 3.38 | .80 | .14 | 77.7 |
| MEAN | 2.27 | .14 | .15 | .31 | 1.84 | 18.0 | 34.4 | 31.6 | 9.48 | 3.92 | .89 | .19 | 103 |

FLOW DURATION - FLOW RANGES IN CUBIC METRES PER SECOND - RECORDS FROM JAN 1966 TO DEC 1982

| FLOW RANGE | | DAYS/ANNUM | FLOW RANGE | | DAYS/ANNUM | FLOW RANGE | | DAYS/ANNUM |
|---|---|---|---|---|---|---|---|---|
| - | .0000 | 28.25 | .07 - | .15 | 29.12 | 6.8 - | 15.0 | 14.69 |
| .0000 - | .0032 | 6.25 | .15 - | .32 | 25.40 | 15.0 - | 32.0 | 11.36 |
| .0032 - | .0068 | 12.53 | .32 - | .68 | 34.02 | 32.0 - | 68.0 | 5.81 |
| .0068 - | .0150 | 20.57 | .68 - | 1.50 | 37.91 | 68.0 - | 150.0 | 2.16 |
| .0150 - | .0320 | 26.05 | 1.50 - | 3.20 | 41.11 | 150.0 - | 320.0 | .27 |
| .0320 - | .0680 | 35.41 | 3.20 - | 6.80 | 30.54 | NO RECORD | | 3.82 |

KEY : NA - NOT AVAILABLE,PERIODS WHEN STATION NOT COMMISSIONED
NR - NOT RECORDED,OR NOT PRESENTLY RATED
BI - BELOW INLET,STAGE BELOW LOWEST LIMIT OF RECORDER

\# - FIGURE DERIVED FROM INCOMPLETE RECORD
* - FAULTY TRACE,BEST POSSIBLE INTERPRETATION
E - ESTIMATED FROM RECONSTRUCTION OF TRACE

APPENDIX 4

SUMMARY OF COMMITMENTS TO ENVIRONMENTAL MANAGEMENT

## SUMMARY OF COMMITMENTS TO ENVIRONMENTAL MANAGEMENT

The following represents a summary of commitments made by Alcoa of Australia Limited in respect of environmental management of the Hedges Gold Mine.

Alcoa of Australia Limited would:

(1) comply with the requirements of applicable Acts and Regulations;

(2) minimise clearing of land consistent with safe and efficient operations;

(3) compensate the State for all clearing of State Forest;

(4) establish environmental regulations for both construction and permanent workforces; ensure that these regulations are complied with through environmental education, supervision and enforcement; take full responsibility for the environmental performance of both permanent employees and sub-contractors;

(5) establish ongoing liaison with Mines Department for pit safety and face stability;

(6) progressively rehabilitate mined areas during the project, if mining sequence and production drilling data indicate that this is possible. Alternatively, rehabilitate all areas after project completion;

(7) where practicable, return waste to mined areas. Landscape and rehabilitate the remaining waste stockpile according to principles in (8);

(8) return affected areas to appropriate and achievable land uses in accordance with agreements with the State Government and Worsley Timber Company, using prescriptions developed in consultation with relevant State Government authorities;

(9) monitor and maintain rehabilitated pits, waste stockpile, haul road and reside disposal areas until such time as it is agreed, with the State, that the objectives of such rehabilitation have been met;

(10) design and operate a water quality, drainage and stormwater management system throughout the project area which will minimise the discharge of turbid water, plant chemicals or tailings spills into nearby streams, and minimise erosion.

(11) ensure mining operations do not have a negative impact on the long term quality of water in the BGM water supply reservoir, by developing and implementing appropriate drainage control and rehabilitation programmes;

(12) monitor stream flow for quality and quantity in 34 Mile Brook upstream and downstream of the mine;

SUMMARY OF COMMITMENTS TO ENVIRONMENTAL MANAGEMENT (contd)

(13) in consultation with CALM, plan and apply appropriate disease control strategies for the haul road alignment through, and mining operations in, State Forest;

(14) apply appropriate dieback management procedures to activities conducted in other forest areas;

(15) conduct forest upgrading planting in disease affected State Forest immediately adjacent to operations, if required and considered appropriate by CALM;

(16) develop a sanitary landfill area for the disposal of office and domestic wastes generated by the project;

(17) if necessary, provide accommodation for the construction workforce following discussions with local authorities;

(18) control fugitive dust from the Project Area;

(19) monitor faunal populations in the Project Area;

(20) restrict human and non-avian faunal access to potentially hazardous areas by fencing. If necessary, contruct and place avifaunal deterrents in the tailings impoundment;

(21) monitor noise levels in the Project Area and its surrounds; use Blast Acoustic Modelling procedure developed at Alcoa's bauxite mine sites to predict and reduce noise impact on Boddington town site and neighbours;

(22) advise nearby populations and relevant Government officers of likely blasting times;

(23) utilise requisite safety equipment and procedures in the handling and storage of hazardous chemicals;

(24) carry out detailed investigations and design of tailings impoundment in accordance with Government requirements. Minimise seepage from the tailings dam by provision of an underdrainage system, by selection of suitable low permeability materials for dam wall construction, and inclusion of seepage cutoff features in the design of the dam wall;

(25) monitor surface water quality in streams immediately downstream of the tailing dam (and plant site) and the water supply dam. Monitor groundwater quality downstream of the tailings dam and implement a detailed monitoring, recovery and recycle/treatment strategy if elevated pollutant levels and detected in seepage or groundwater;

(26) in the event of contaminated groundwater being detected, be prepared to establish a recovery bore system downflow of the tailings area;

(27) modify residue management system and operations to the reasonable satisfaction of the State if unexpected problems occur;

SUMMARY OF COMMITMENTS TO ENVIRONMENTAL MANAGEMENT (contd)

(28) notify the Water Authority, EPA and downstream users promptly if any spillage occurs which has potential to affect downstream water users; conduct clean-up or containment operations if necessary;

(29) remove contaminated material and carry out appropriate rehabilitation if a tailings pipeline failure occurs;

(30) establish surface contouring and drainage to prevent the rise of contaminated waters in residue areas during rehabilitation, and permit vegetation establishment. Establish a drainage collection system to retain runoff so that it can be monitored and if necessary treated prior to discharge;

(31) continue monitoring the water residue system until it is decided, in consultation with the State, that such activity is no longer required;

(32) carry out investigations in conjunction with WAJV, or independently, on residual process chemicals in the gold tailings and their possible effects on underlying soils and groundwater. Include a comprehensive survey after the first 12 months operation of the chemical status of the tailings deposit;

(33) keep abreast of developments in gold tailings disposal technology for possible future application in treating contaminated seepage or runoff if it proves necessary;

(34) provide access for CALM and local Bush Fire Brigades;

(35) submit an annual report of environmental management and monitoring programmes, then content of which is to be determined by agreement with the State;

(36) construct more positive cut off features or seepage collection systems for the tailings dam, if unacceptable seepage occurs;

(37) design the initial tailings dam and its extensions to store runoff from a net year with a 1:1000 year frequency;

(38) carry out or sponsor studies on the interactions between tailings leachate and foundation soils after the commencement of operations;

(39) carefully monitored water quality changes prior to and following start-up and if adverse trends develop then measures will be taken to protect downstream uses;

(40) in the event that unacceptable water pollution occurs downstream, carry out remedial action to the satisfaction of the State;

(41) process make-up water would be drawn from the Hotham River during the winter months when salinities can be in the range 1000-9000 mg/l;

(42) commence a hydrogeological monitoring and assessment programme prior to start-up and would update it continuously;

SUMMARY OF COMMITMENTS TO ENVIRONMENTAL MANAGEMENT (contd)

(43) monitor the water and salt balances for the tailings circuit;

(44) ensure that mining of the stream zone orebody only took place during summer months and that rehabilitation of this part of the pit would commence immediately mining was completed;

(45) with regard to monitoring of water quality and quantity of 34 Mile Brook, coordinate monitoring with that of BGM and WAWA requirements;

(46) ensure that domestic waste disposal within the the 34 Mile Brook Catchment would use self contained toilets and enclosed garbage bins;

(47) establish a correlation between the minimum flow at the Marradong Gauging Weir and the river level at pump suction. An automatic cutoff system would ensure that pumping leases at this time;

(48) transport chemicals according to standard government safety requirements;

(49) provide access for fire control purposes; and

(50) take action to the reasonable satisfaction of the State if actual or potential risks, not adequately addressed in this ERMP, occur.