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**Report and Recommendations
by the
Environmental Protection Authority**

**Proposed Aluminium Smelter — Kemerton
International Aluminium Consortium
of Western Australia**



Department of Conservation and Environment,
Perth, Western Australia

Bulletin 214 June 1985

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Foreword

The preparation of this Assessment Report was concluded in June 1985, and was based on the information available to the Authority at that date.

Prior to presentation of this Assessment Report to the Minister for the Environment, the Western Australian Government announced that the proposed aluminium smelter at Kemerton would not be proceeded with at this time. The Authority has completed its assessment of this proposal despite this announcement, in the belief that its advice will be of assistance to Government in the event that a smelter is again proposed. In view of the rapid change in technology and in the light of information obtained in the future, through programmes such as the proponent-funded Authority studies, the Authority considers it prudent to indicate that this assessment should not be considered to be operative for more than five years.

The International Aluminium Consortium of Western Australia (the proponent) consisted of the following parties at the time of release of the ERMP:

A Korean entity to be approved by the Government of the Republic of Korea	45%
Griffin Aluminium Pty Ltd	25%
The State of Western Australia, represented by the Western Australian Development Corporation	20%
Reynolds Australia Aluminium Ltd	10%

Its composition has changed since that time.

Executive Summary and Recommendations

Executive Summary and Recommendations

The Environmental Protection Authority has concluded its review of the ERMP and other documents prepared on this project. The Authority's Assessment Report will assist the design, implementation and management of this proposal.

Documentation

Several aspects of the ERMP document were disappointing, including the shortage of description on the resilience of the environment to change and the commitment to environment management.

Some matters identified in the Guidelines issued by the Authority were not addressed, and there was no explanation of their omission.

There were also inadequacies in:

- the Supplement; and
- the proponent's written responses to comments and questions.

The Authority has been able to reach certain conclusions assisted by a consideration of its previous investigations, by related documentation prepared by others, and by public comments.

Suitability of the Kemerton area for an aluminium smelter

The Authority concludes that the Kemerton area (i.e. the area addressed by the Conceptual Land Management Plan) is an acceptable location for an aluminium smelter subject to a series of recommendations including the following:

- the development and implementation of a land management plan for the buffer zone, which recognises its prime function as a fluoride sink;
- the adoption of the Authority's major recommendations;
- the adherence by the proponent to the commitments given (as summarised in Appendix K); and
- the development of an appropriate Environmental Management Programme.

However, the chosen location within the Kemerton area may present difficulties, because of the shallow depth of the water table. More detailed studies may indicate that more suitable sites may be available within the boundaries of the Kemerton buffer area. A change in the specific site for the smelter, or even a change in orientation of the potlines, would necessitate re-submission of details to the Authority to evaluate the change in potential impacts.

Similarly, a shallow water table may imply a need for foundations needing the excavation and removal of large amounts of earth. If other than a standard cut-and-fill operation was proposed the impact would need to be assessed by the Authority.

Suitability of the Worsley Siding area for an aluminium smelter

The Authority concludes that Worsley Siding is an environmentally unsuitable site for an aluminium smelter, principally because of the potential effects of fluoride on the jarrah forest. Although only limited information is available at present, it is considered most unlikely that additional information would lead to a different conclusion.

Study Programme

The Authority recommends that the Study Programme now in progress should continue as planned : the results obtained will be valuable in the preparation of the Environmental Management Programme. These studies address:

- field assessment of soils and vegetation;
- effects of gaseous fluoride on trees;
- effects of fluoride on soil and groundwater; and
- effects of fluoride on irrigated pastures.

Environmental Management Programme

The proposal is still at a conceptual stage. Responses to the many issues raised in the Assessment Report should be incorporated into the Environmental Management Programme (EMP). The EMP should be prepared by the Consortium in consultation with the Authority and the Department of Resources Development, and when finalised should be published.

Emission limits

With respect to emission limits, the Authority concludes that:

- an annual emission rate of 1.0 kilogram of total fluoride per tonne of aluminium produced should never be exceeded. This level coincides with the upper limit at which predictions suggest that only minimal impacts will occur beyond the buffer region;
- an emission rate of 0.75 kilogram of total fluoride per tonne of aluminium produced should be set as an objective. This level is close to that set for recent projects in Eastern Australia; and
- irrespective of the size of the smelter, it should be restricted to a maximum annual emission load of 230 tonnes per annum of total fluoride. Such a limit should contain impacts to the buffer area.

Solid waste

The proponent should provide details to the Authority on the interim storage and disposal of all solid waste. Any method of storage should be designed so as to prevent the formation and escape of leachate.

Proposals for long-term treatment, storage, or disposal of contaminated waste should be provided to the Authority for assessment within two years of the commencement of operation.

Contaminated liquid waste

The EMP should provide a comprehensive account of liquid waste disposal methods, as proposed. The management of the proposed disposal methods will need to be subjected to environmental assessment, and included in the EMP.

Community Needs Study

The recently released Community Needs Study provided a framework for the evaluation of the social impacts of the proposal. Assessment by the relevant authorities would have been improved if this report had been available with the release of the ERMP, and been subject to public review. Effective management of social needs would require that officers with co-ordinating responsibilities be based in the region.

The Assessment Process

The assessment of this proposal has provided an important learning process. In future it will be important to reach early agreement between all 'proponent' parties and the Authority on the scope of matters requiring assessment. Clearer lines of responsibility and accountability should be established, resulting in the assessment process being more effective for all parties.

RECOMMENDATION 1:

The EPA recommends that the Worsley Siding site is an environmentally unsuitable site for an aluminium smelter.

RECOMMENDATION 2:

The EPA recommends that, in order to determine the suitability of the site for construction of a smelter, the proponent should undertake the following groundwater surveys:

- a comprehensive investigation of the Kemerton area; and
- a detailed investigation of the proposed smelter site.

The results of these surveys, which should form part of the proponent's overall engineering assessment of the site, should be reported to the EPA early in the detailed design phase of the project.

RECOMMENDATION 3:

The EPA recommends that a change in the specific site of the smelter, or a change in orientation of the potlines, would necessitate re-submission of details to the EPA to evaluate the change in potential impacts.

RECOMMENDATION 4:

The EPA recommends that, in order to protect residents in surrounding areas, the proponent should undertake dust control measures wherever necessary to comply with the relevant National Health and Medical Research Council (NH & MRC) guidelines for inert nuisance particulates in ambient air. Furthermore, in controlling dust in the workplace, the proponent should comply with the NH & MRC occupational health guidelines for threshold limit values.

RECOMMENDATION 5:

The EPA recommends that the proponent takes the following actions for management of construction-phase wastes:

- sewage should be stored in tanks and regularly pumped out for transport and disposal at established treatment plants or at approved liquid waste disposal sites, until such time as a package sewage treatment plant is in operation;
- solid building wastes should be disposed of in on-site pits to be progressively excavated, filled, and rehabilitated; and
- all other wastes produced should be disposed of in a manner satisfactory to the relevant authorities.

RECOMMENDATION 6:

The EPA recommends that, within the proposed smelter site, the proponent should establish as early as possible prior to construction:

- tree plantations throughout the site to absorb fluoride, except where development precludes this; and
- forest fire management measures in conjunction with those of the Department of Conservation and Land Management for the Kemerton area (See also Recommendation 27).

RECOMMENDATION 7:

The EPA recommends that the proponent should consult with and obtain the approval of all relevant authorities, on the siting, establishment and management of the camp, associated facilities (including sewage treatment plant) and access corridors. Should the proposed site lie within the buffer zone, then it will be necessary to involve the Department of Conservation and Land Management.

RECOMMENDATION 8:

The EPA recommends that if foundation requirements are such that the proponent needs to excavate and remove large amounts of earth, and/or if the proponent proposes other than a standard cut-and-fill operation on the site, these should be referred to the EPA for environmental assessment.

RECOMMENDATION 9:

The EPA recommends that:

- an annual emission rate of 1.0 kilogram of total fluoride per tonne of aluminium produced shall never be exceeded;
- an emission rate of 0.75 kilograms of total fluoride per tonne of aluminium produced should be set as an objective; and
- irrespective of the size of the smelter, it should be restricted to a maximum emission load of 230 tonnes of total fluoride per annum.

RECOMMENDATION 10:

The EPA recommends that the proponent should demonstrate in the Environmental Management Programme (EMP) the environmental acceptability of the proposed methods of liquid waste disposal.

RECOMMENDATION 11:

The EPA recommends that the proponent should address in the EMP its proposals for the disposal of non-contaminated wastes.

RECOMMENDATION 12:

The EPA recommends that the proponent should provide details to the EPA on the interim storage and disposal of all solid waste. Any methods of storage should be designed so as to prevent the formation and escape of leachate.

RECOMMENDATION 13:

The EPA recommends that proposals for long-term treatment, storage or disposal of contaminated waste should be provided by the proponent to the EPA for assessment within two years of the commencement of operation.

RECOMMENDATION 14:

The EPA recommends that the proponent should be required to comply with prevailing noise control legislation and regulations.

RECOMMENDATION 15:

The EPA recommends that effective management of social needs would require that officers with co-ordinating responsibilities be located in the region.

RECOMMENDATION 16:

The EPA recommends that the consequential planning implications of establishing an aluminium smelter in the Kemerton area should be identified by the Town Planning Department and duly considered and that in such consideration, environmental issues should be thoroughly addressed.

RECOMMENDATION 17:

The EPA recommends that monitoring of the total airshed pollution load at Bunbury should continue.

RECOMMENDATION 18:

The EPA recommends that any significant potential environmental impact associated with the acquisition and transport of large quantities of basic raw materials to be used in the construction of the proposed smelter, should be referred to the EPA so that the environmental impacts can be assessed.

RECOMMENDATION 19:

The EPA recommends that, in view of specific commitments by the proponent, a mechanism of compensation for fluoride impacts should be established and details provided in the EMP.

RECOMMENDATION 20:

The EPA recommends that, in anticipation of increased recreational activity and consequent environmental impacts, relevant State and local government agencies should formulate appropriate strategies.

RECOMMENDATION 21:

The EPA recommends that the proponent prepares an Environmental Management Programme which addresses *inter alia*:

- any amendments to the proposal as described in the ERMP;
- relevant design information;
- all matters identified in this Assessment Report as needing consideration in the EMP;
- the application of the results of the EPA Study Programme to project design and management;
- proposals for environmental monitoring and management including contingencies;
- mechanisms for the modification of management during project interruption at any stage;
- proposals for environmental management during project interruption at any stage; and
- proposals and/or commitments for decommissioning and rehabilitation.

RECOMMENDATION 22:

The EPA recommends that, in the light of the continuing need for input on environmental issues, the EMP should be prepared by the proponent in consultation with the EPA and the Department of Resources Development, and when finalised should be published.

RECOMMENDATION 23:

The EPA recommends that the proponent submits reports to the EPA on the monitoring and management programmes as follows:

- an annual report reviewing the year's progress on environmental monitoring and management, outlining proposed changes to the current three-year programme; and
- a triennial report in which the previous three years' environmental monitoring and management are reviewed, the proposed programmes for the forthcoming three years are presented, and proposed amendments to the EMP are detailed.

RECOMMENDATION 24:

The EPA recommends that the proponent takes the necessary management actions, prior to commencement of the construction phase, to achieve the environmental objectives stated in this Assessment Report.

RECOMMENDATION 25:

The EPA recommends that the Department of Conservation and Land Management monitors ground-water and wetland water levels both as a component towards ongoing management of the wetlands, and to assist in determining any long-term effects that the proposed pine plantation might have on the water regime of the Kemerton area.

RECOMMENDATION 26:

The EPA recommends that, in view of the known occurrence of rare and endangered species, a study be undertaken by the Department of Conservation and Land Management to identify those aspects of the floral communities in the buffer zone that have conservation value and may need appropriate management. This study should be completed prior to development in the Kemerton area.

RECOMMENDATION 27:

The EPA recommends that a detailed land management plan for the Kemerton area should be prepared and implemented as soon as possible. The provisions of this plan should be compatible with the operation of a smelter within the area, and should include an appropriate fire management plan.

RECOMMENDATION 28:

The EPA recommends that any significant potential environmental impact associated with the alignment, construction and operation of the railway should be referred to the EPA so that the environmental impacts can be addressed.

RECOMMENDATION 29:

The EPA recommends that consideration be given by SECWA and Westrail to locating the proposed natural gas pipeline lateral within the proposed railway easement to the aluminium smelter, and that SECWA continues to liaise with the EPA.

RECOMMENDATION 30:

The EPA recommends that the Study Programme now in progress should continue as planned: the results obtained will be valuable in the preparation of the Environmental Management Programme. These studies address:

- field assessment of soils and vegetation;
- effects of gaseous fluoride on trees;
- effects of fluoride on soil and groundwater; and
- effects of fluoride on irrigated pastures.

RECOMMENDATION 31:

The EPA recommends that the Kemerton area (i.e. the area addressed by the Conceptual Land Management Plan) is an acceptable location for an aluminium smelter subject to a series of recommendations including the following:

- the development and implementation of a land management plan for the buffer zone, which recognises its prime function as a fluoride sink;
- the adoption of the EPA's major recommendations;
- the adherence by the proponent to the commitments given (as summarised in Appendix K); and
- the development of an appropriate Environmental Management Programme.

LOCATION TERMS

Reference is made at various points throughout the Assessment Report to several specific areas and sites relating to the location of the proposed smelter, and to various considerations being either on-site or off-site. These locations are described in the following terms:

1. Smelter site — is the 400 hectare site on which the proposed smelter would actually be constructed. In the ERMP, this is referred to as the Kemerton site.
2. Kemerton area/Buffer zone/Buffer area — is the area within the boundaries of the Conceptual Land Management Plan — Kemerton Area prepared by the Forests Department of W.A.
3. On-site — applies only within the 400 hectare smelter site.
4. Off-site — applies beyond the 400 hectare smelter site.

Figure 1 indicates the areas encompassed by these terms.

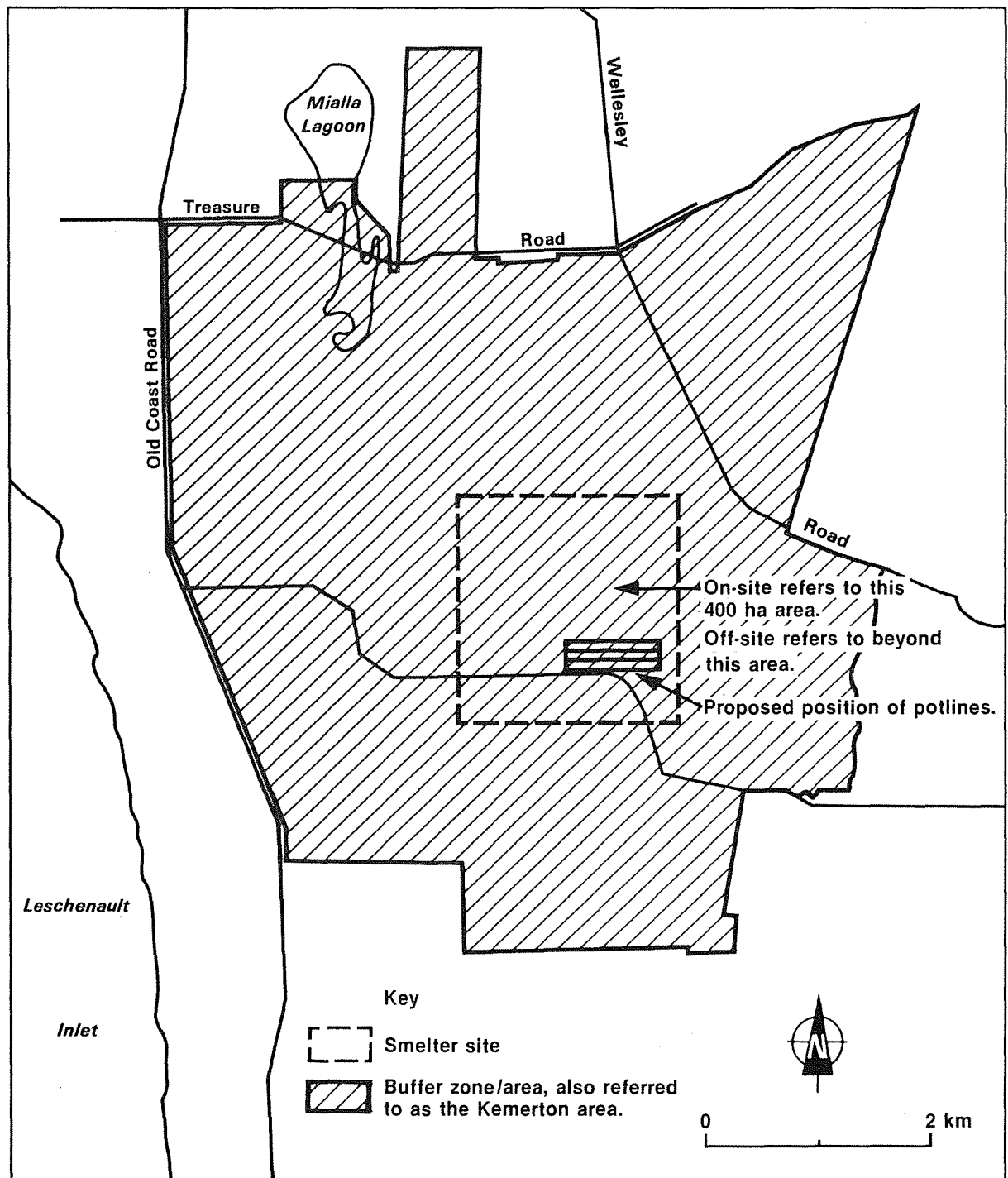


Figure 1 — Areal Extent of Locational Terms Used in This Assessment Report.

1. INTRODUCTION

1.1 ENVIRONMENTAL IMPACT ASSESSMENT

The primary objective of the environmental impact assessment (EIA) process in Western Australia is to ensure that environmental factors are considered by proponents and decision-makers when a new project is proposed.

1.2 HISTORICAL BACKGROUND TO THE PROPOSAL AND THE AUTHORITY'S INVOLVEMENT IN SITE SELECTION

State Governments have, over recent years, been of the view that the establishment of an aluminium smelter in Western Australia would be a logical and significant stage in the further processing of the State's raw materials, in this instance bauxite. An indication of this desire is the inclusion of a clause in the Alumina Refinery (Pinjarra) Agreement Act and the Alumina Refinery (Worsley) Agreement Act which requires Alcoa of Australia Ltd and Worsley Alumina Pty Ltd respectively to investigate the technical and economic feasibility of establishing a smelter in Western Australia.

Investigations into potential smelter sites were commenced by Alcoa in 1980, and continued for approximately three years. Detailed assessment of fourteen sites was carried out; these sites coincide with those mentioned in Section 3.3.1. By early 1983, preliminary documentation on site selection had been prepared by Alcoa, in conjunction with ICC Construction Co. Ltd, and this was provided to the Authority. This report indicated that three sites were preferred for further studies, Kemerton, Worsley Siding and Pinjarra.

Discussions took place with the Authority in February 1983 after which it inspected several of the potential sites. A final site had not been selected at this time. Shortly after this, Alcoa withdrew from the smelter investigations.

When a Notice of Intent (NOI) was formally submitted to the Authority in January 1984 by Kukje — ICC Construction, the preferred sites had been reduced to two, Kemerton and Worsley Siding. Although no reasons for its exclusion were presented in the NOI, the Authority understands that modelling of air emissions at the Pinjarra site would have been extremely difficult.

1.3 DOCUMENTATION PREPARED ON THE PROPOSED SMELTER

1.3.1 THE PROPONENT'S DOCUMENTS

On the basis of the Notice of Intent submitted by Kukje — ICC Construction, the Authority considered that an Environmental Review and Management Programme (ERMP) was warranted. This Notice of Intent was also considered by the Commonwealth, and the preparation of an Environmental Impact Statement (EIS) was directed. Subsequently, the respective Ministers agreed on co-operative procedures for the handling of the assessment, pursuant to the Memorandum of Understanding.

Draft Guidelines were prepared by both Governments in consultation with the proponent: these were formally issued in September 1984 (Appendix A).

The Draft EIS/ERMP (hereinafter termed the ERMP) was prepared by the International Aluminium Consortium of Western Australia (hereinafter referred to as the proponent) and released for an eight-week public comment period ending on 1 May 1985.

During this period the Authority sought comments from a wide range of Government agencies. A total of twenty such responses were received, which were forwarded to the proponent and the Commonwealth Government.

The proponent prepared a Supplement to the Draft EIS; together, these constitute the Final EIS required by the Commonwealth. In this Supplement, which was received by the State and Federal Governments on 27 May 1985, the proponent addressed all public comments received before 1 May 1985.

The proponent also prepared two further documents responding respectively to the comments made by government agencies, and to a wide range of questions which had been asked by the Authority. These responses were received on 27 May 1985.

The receipt of the Supplement triggered the commencement of a Commonwealth statutory twenty eight-day period during which the Commonwealth Department of Arts, Heritage and Environment prepared its Assessment Report. The Authority prepared this Assessment Report during the same period.

1.3.2 OTHER DOCUMENTS

Table 1 lists other documents which have been prepared on aspects relating to the proposed smelter, and considered by the Authority in the preparation of this Assessment Report.

Table 1 Other documents considered in the preparation of this report.

PUBLIC DOCUMENTS	DATE OF PUBLIC RELEASE
Town Planning Scheme No. 10, Amendment No. 10 - Shire of Harvey	16 February 1985
Public Environmental Report on Proposed Transmission Line Interconnections for Proposed Aluminium Plant (Kemerton) - State Energy Commission WA	7 March 1985
Conceptual Land Management Plan - Kemerton Area - Forests Department	7 March 1985
Economic Aspects of the South West Aluminium Smelter Project - Department of the Premier and Cabinet	9 April 1985
Aluminium Smelter Services Corridor Study - Dames and Moore	17 April 1985
Community Needs Study: A Socio-Economic and Social Impact Assessment of the Proposed Kemerton Aluminium Smelter - Dames and Moore	18 June 1985
AUTHORITY'S STUDY REPORTS	
Preliminary Results of Soil and Groundwater Studies: Proposed Aluminium Smelter - Dr G. Ho, Murdoch University	
A Preliminary Field Assessment of Soils and Vegetation at the Kemerton Site - G.M. Dimmock, F.J. Hingston, CSIRO Div. of Forest Research	

1.4 ADDITIONAL STAFF RESOURCES USED IN THE ASSESSMENT

The Authority wishes to acknowledge that the State Government made additional staff resources available, together with funds to employ expert consultants, to assist in the assessment of this proposal. These provisions have been of considerable assistance to the Authority.

1.5 STRUCTURE OF THIS ASSESSMENT REPORT

The remaining chapters of this Assessment report address the following matters:

- THE SMELTER ASSESSMENT PROCESS (CHAPTER 2)
- SITE SELECTION WITHIN THE REGIONAL ENVIRONMENT (CHAPTER 3)
- EXISTING ENVIRONMENT AT KEMERTON (CHAPTER 4)
- THE PROPOSAL (CHAPTER 5)
- REVIEW OF SUBMISSIONS (CHAPTER 6)

- BIOPHYSICAL IMPACT ASSESSMENT (CHAPTER 7)
- SOCIAL IMPACT ASSESSMENT (CHAPTER 8)
- CUMULATIVE IMPACTS AND INTERACTIONS (CHAPTER 9)
- ENVIRONMENTAL MANAGEMENT AND MONITORING (CHAPTER 10)
- ISSUES REQUIRING RESOLUTION FOLLOWING THIS ASSESSMENT (CHAPTER 11)
- CONCLUSION (CHAPTER 12)

During the preparation of this Assessment Report the Authority has considered a wide range of related matters, many of which (e.g. the Conceptual Land Management Plan — Kemerton Area) have been of considerable importance in evaluating the significance of the impacts of the smelter. Others concern related proposals (e.g. the infrastructure corridors) which are of direct relevance in considering the cumulative environmental impacts. The Authority has also had regard to a number of related studies (e.g. the Community Needs Study released by the Government). Finally, the Authority has included technical appendices in this Assessment Report (e.g. the biological effects of fluorides, and an outline of the Authority's Study Programme).

Although all these are of direct relevance to an understanding of this Assessment Report, the Authority has endeavoured to keep the main sequence of the document's narrative uninterrupted by detailed considerations of such matters. Accordingly, it has made extensive use of Appendices, which are cross-referenced in the main body of the Assessment Report. A full list of Appendices is given below:

- A) Proposed Aluminium Smelter: Guidelines for an ERMP/Draft EIS.
- B) Environmental Studies being Undertaken for the Authority.
- C) Proposed Transmissions Line Interconnections for the Aluminium Smelter (State Energy Commission of Western Australia): Report and Recommendations by the Environmental Protection Authority.
- D) Infrastructure Requirements of the Aluminium Smelter (Dames and Moore 1985a).
- E) Conceptual Land Management Plan — Kemerton Area (Forests Department).
- F) Brief Description of Sites.
- G) List of Submissions on the ERMP from the Public and from Community Organisations.
- H) The Relationship between Fluoride in Air and Fluoride in Forage.
- I) The Biological Effects of Fluoride.
- J) Community Needs Study: Summary and Recommendations (Dames and Moore 1985b).
- K) Commitments and Key Statements by Proponent.

2. THE SMELTER ASSESSMENT PROCESS

The preparation of this Assessment Report by the Authority has had a number of unusual features. These are identified in this Chapter under the following headings:

- responsibilities (Section 2.1);
- development of a staged process (Section 2.2);
- site selection process (Section 2.3);
- information quality and timing (Section 2.4).

2.1 RESPONSIBILITIES

For previous major assessments on which the Authority has prepared an Assessment Report, there has been a relatively streamlined process beginning with a Notice of Intent, issue by the Authority of Guidelines for the ERMP, preparation and release of an ERMP for public comment (often with supporting documents), and concluding with the preparation of an Assessment Report by the Authority (Figure 2).

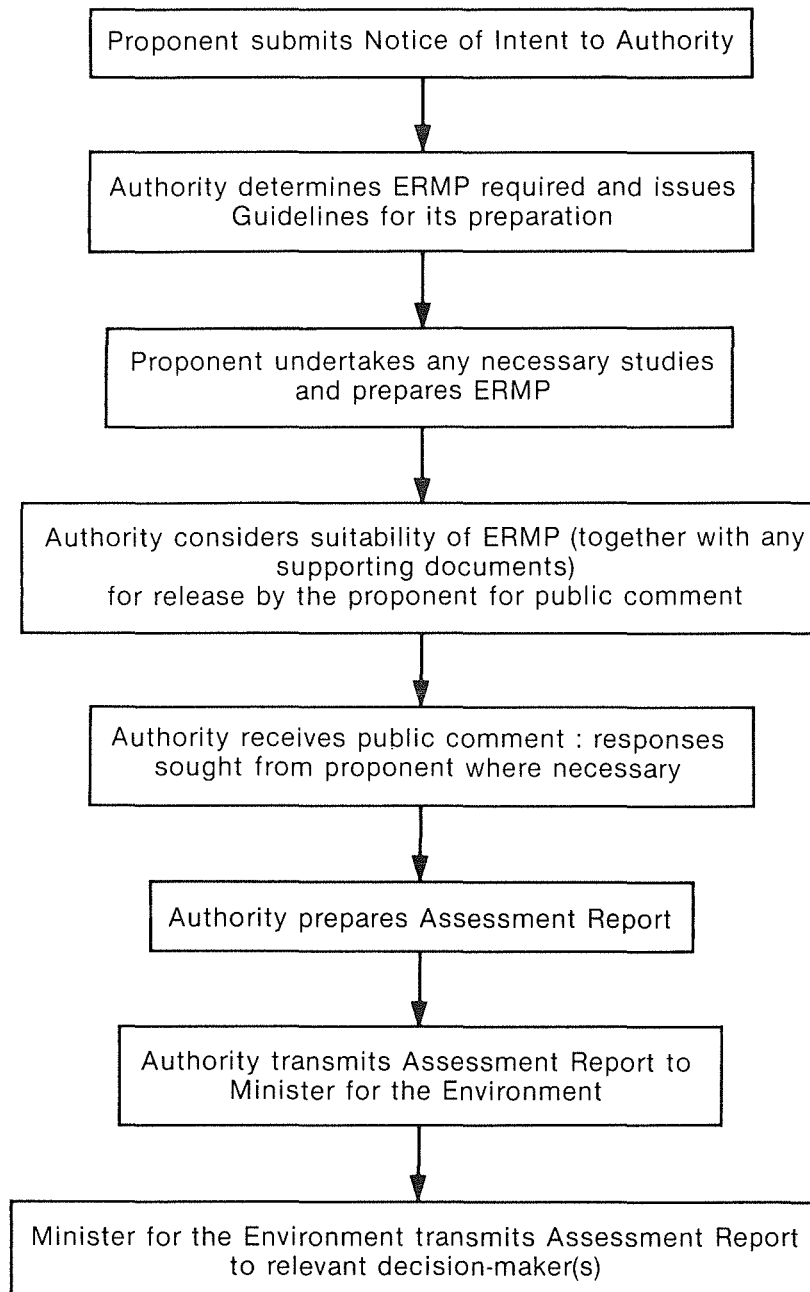


Figure 2 — The Western Australian EIA Process for a Major Project Requiring the Preparation of an ERMP.

In this instance the process has been more complex. The ERMP was released together with a package of related documents prepared by other proponents or authors. This in turn was followed by further documentation during and after the public review period on the ERMP. A number of these documents (notably the Community Needs Study) went a considerable way to overcoming deficiencies in the ERMP; however, others were at variance with the ERMP.

Some of the documents were issued and invited formal public comment, whereas others were issued only for public information. All the documents are identified in Table 1. The Authority has needed to consider all documents associated with the smelter in the preparation of this Assessment Report.

The Government established an Aluminium Smelter Task Force. In addition, a number of government agencies have been the proponents for associated infrastructure (e.g. the State Energy Commission of WA (SECWA) is the proponent of two transmission line corridors, and the Department of Resources Development (DRD) of a services corridor). The Forests Department (now part of the Department of Conservation and Land Management (CALM)) is the proponent for management of the buffer zone.

On occasions, the respective roles of the proponent and government agencies were unclear.

Such difficulties in the assessment of major proposals may be minimised if initially there is agreement between all "proponent" parties and the Authority on the scope of matters requiring impact assessment. Agreement could then be reached on respective responsibilities and the sequencing of events (including documentation). In this way, clear lines of responsibility and accountability can be established, thereby facilitating the impact assessment process.

2.2 DEVELOPMENT OF A STAGED PROCESS

The decision by the State Government to acquire land at Kemerton, announced in a press release by the Premier on 5 December 1984, effectively determined the Kemerton site as the location for the smelter, as explained in Section 3.5 of the ERMP. This is addressed further in Sections 2.3 and 3.3 of this Assessment Report.

When this announcement was made, there was insufficient information available about certain important aspects of the Kemerton environment to enable the proponent to give full consideration to proposed environmental management in the ERMP. In particular, the response of native vegetation and wetlands to fluoride, and the fate of fluoride in the soils were unknown. It was also realised that the time constraints of the proposal, which effectively dictated the latest possible timing for environmental impact assessment, would preclude the collection of all the information necessary for preparation of a single stage ERMP.

It was therefore agreed between the Authority, the Government, and the proponent, that

- the ERMP would give only preliminary consideration to proposed environmental management;
- the proponent would fund a twelve-month Study Programme to be carried out for the Authority to investigate important areas of uncertainty (Appendix B); and
- the proponent would prepare the management programme component of the ERMP in the light of the results of the study programme at some later date (i.e. essentially the second stage of the ERMP).

When this was agreed, the Authority did not specify how the second stage of the ERMP would be related to the formal requirement for an approved Environmental Management Programme (EMP) normally required under an Agreement Act, as the final timing and content of the Agreement Act were not known. Further discussion on this is given in Section 10.4.

2.3 SITE SELECTION PROCESS

As explained in Section 1.2, the Authority has been involved in the consideration of smelter proposals for several years. The Authority has been formally aware of the current aluminium smelter proposal since it received a Notice of Intent in January 1984.

In that document, a preference was expressed by the proponent for a site at either Worsley Siding or Kemerton.

As noted in Section 2.2, the Government's announcement late in 1984, that it intended to acquire land at Kemerton (which could be managed as a buffer zone to the smelter) essentially resolved the uncertainty of the proponent and Government about the probable site for the smelter.

The Authority considered, at the time of the Government's announcement, that Kemerton was a much better site on environmental grounds than Worsley Siding. The Authority is still firmly of this view, as explained in Section 3.3.

2.4 INFORMATION QUALITY AND TIMING

2.4.1 QUALITY OF THE PROPONENT'S DOCUMENTS

The Authority considers that the ERMP was an inadequate document because of deficiencies in the following areas:

- baseline environmental information presented;
- technical information, in particular smelter technology to be adopted, sources of noise, levels of air emissions;
- prediction and assessment of significant environmental impacts;
- commitments to environmental management; and
- some issues identified by the Authority in the Guidelines (Appendix A) were not addressed at all.

Similar comments also apply to:

- the Supplement; and
- the proponent's written responses to submissions, comments and questions raised by the public, government agencies and the Authority.

2.4.2 QUALITY AND TIMING OF OTHER DOCUMENTS

As noted in Section 1.3.2, a number of other documents were prepared on the proposal. The quality and timing of some of these have presented some difficulties in the assessment process, including the following:

- the Community Needs Study which examined the socio-economic and social impact assessment of the proposed smelter is a sound document. However, its release at the same time as the ERMP would have enabled the Authority to have regard to public comment and enabled the public to understand better the proposal;
- the Conceptual Land Management Plan — Kemerton Area did not consider the potential impact of the smelter;
- the documentation on the infrastructure corridor was not released at the same time as the ERMP, thereby constraining the public's ability to comprehend the environmental implications of the project as a whole. This is in contrast to SECWA's PER on the transmission line corridors which is an excellent document, and which was released at the same time as the ERMP.

2.4.3 GOVERNMENT AGENCY COMMENTS

Comment on the ERMP was received from a number of State Government agencies. These were circulated to the Commonwealth Department of Arts, Heritage and Environment and to the proponent for their information and consideration. The proponent has responded to these in a separate submission to the Authority. The information contained in the original comments, and the proponent's responses thereto, have been considered by the Authority in the preparation of this Assessment Report.

2.4.4 TIME CONSTRAINTS

There have been significant time constraints in the assessment process. In part these have arisen from the proponent's stated need to obtain the benefits of the investment allowance which expires on 30 June 1985. This has resulted in the following:

- a public review of eight weeks, which for a project of this nature is an absolute minimum;
- a period of four weeks to prepare the Assessment Report; and
- limited availability of other documents needed for the assessment (e.g. Community Needs Study and Services Corridor Study) because of lack of time to prepare them.

2.5 CONCLUSION

Having identified these matters, subsequent Chapters present the Authority's findings on the environmental aspects of the proposal, and are based on consideration of information additional to that presented in the ERMP.

3. SITE SELECTION WITHIN THE REGIONAL ENVIRONMENT

3.1 ELEMENTS OF A SMELTER AND CRITERIA FOR SITE SELECTION

3.1.1 ELEMENTS OF A SMELTER

Primary aluminium is produced by the electrolytic reduction of alumina. A smelter consists of cells* (or pots) where the reduction process takes place, casting facilities to produce the final product and essential plant for the manufacture of cell components.

The major built elements of a smelter are the potrooms* which are large sheds, the dimensions of which are about 800m x 20m with a height of 22m. Two potrooms joined at the end constitute a potline. They are the predominant elements on Figure 3 which is an artist's impression of the proposed smelter. Each potline has a capacity of 115000 tonnes per year (tpy) of primary aluminium, and two potlines containing four potrooms are proposed, each room containing 120 pots.

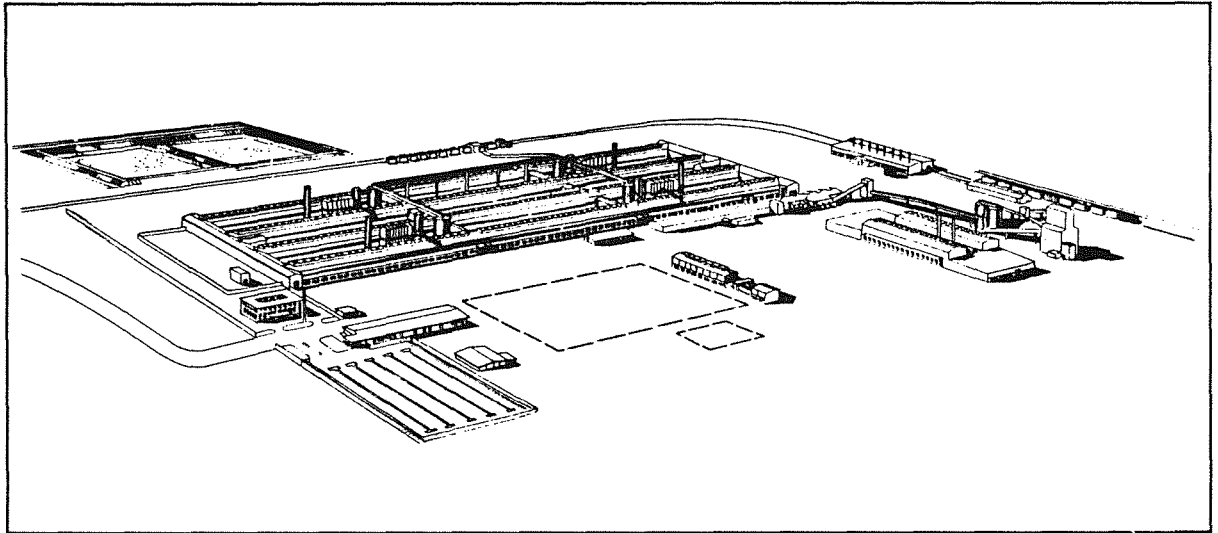


Figure 3 — Artist's Impression of Proposed Aluminium Smelter (viewed from the north).

Experience with aluminium smelters in other parts of the world has demonstrated that for operational reasons a minimum separation of 4m, and preferably more than 6m, must be maintained between the reduction cells and the highest anticipated groundwater level. Similarly the anode bake furnace must be located at least 5m above underlying groundwater.

Other large-scale built elements are:

- raw material storage facilities for storing alumina, pitch and petroleum coke;
- anode production facilities, consisting of the green carbon* mill, baking furnace and rodding* mill;
- ingot mill; and
- emission control facilities and associated stacks*. Stacks are generally built to clear nearby buildings enough to ensure adequate dispersion of emissions and are also kept as low as practicable to contain the emissions close to the smelter site.

3.1.2 MAJOR PROCESS INPUTS AND OUTPUTS

The major inputs and outputs for a 230000 tpy smelter are shown in Figure 4. The quantities given are also specific to this proposal and are addressed elsewhere, in Chapter 5.

3.1.3 ESSENTIAL OPERATIONAL INFRASTRUCTURE ELEMENTS

A smelter requires essential servicing to guarantee its continuous operation. These infrastructure elements are listed below:

- raw material inputs (see Section 3.1.2 and Figure 4);
- energy supply, including transmission lines, and gas pipeline (see Appendices C and D);
- adequate transport network both road and rail (see Appendix D);
- port facilities (see Appendix D);
- water supply (see Section 7.2.2);
- workforce (see Chapter 8);

* denotes term defined in Glossary

- telecommunications (see Appendix D);
- suitable land for smelter and infrastructure (see Chapters 3, 4, 7, 8, 9 and Appendices B, C, D, E, F and I); and
- waste disposal (see Sections 5.4, 5.5, and Chapters 7 and 11).

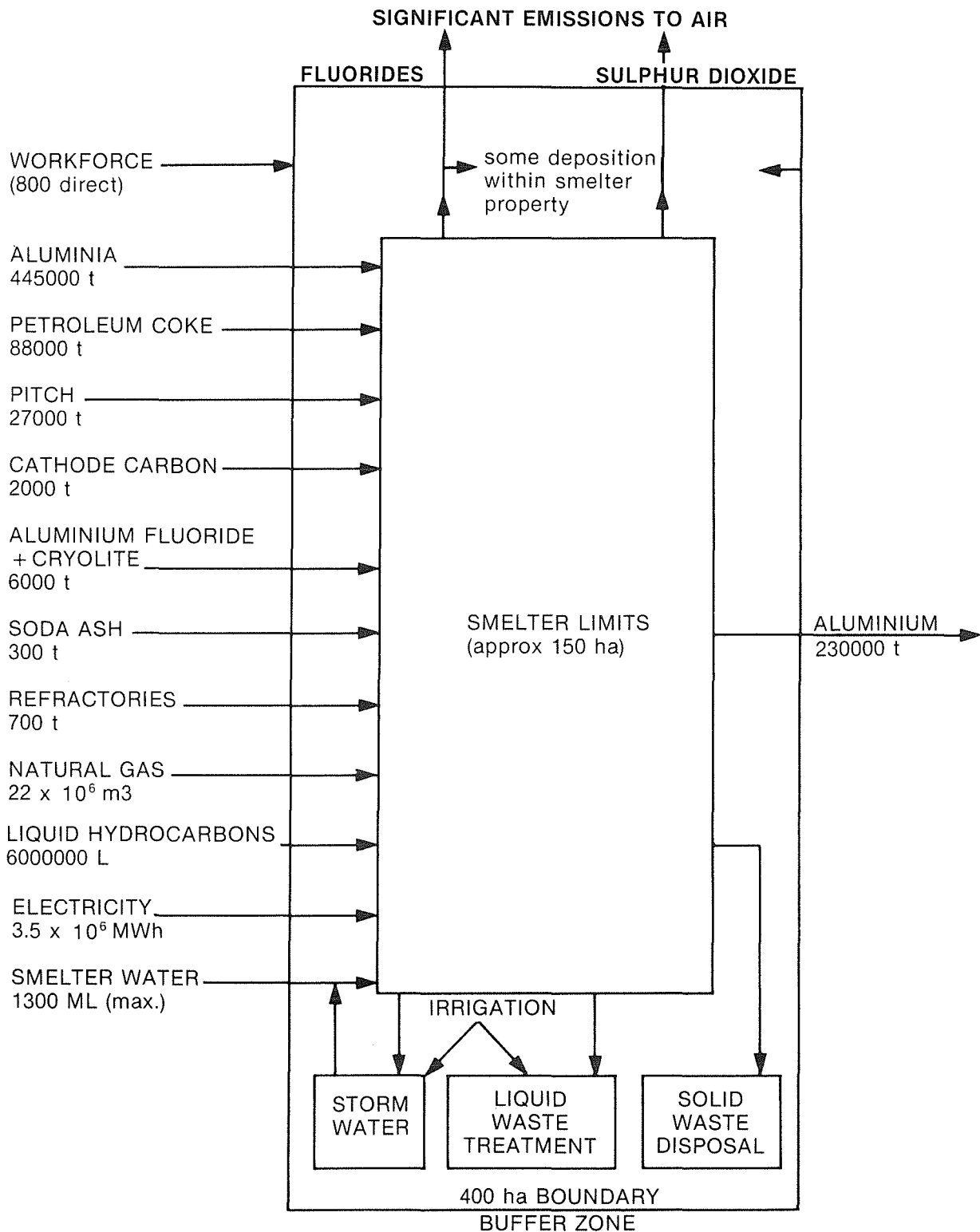


Figure 4 — Major Inputs and Outputs of a Smelter (annual)

3.1.4 REGIONAL CRITERIA FOR SITE SELECTION

From an examination of smelter proposals for the aluminium industry in Australia it has become evident that the dominant criteria for site selection are of a regional nature. The essential regional factors summarised below have been compiled from the proponent's ERMP, the Alcoa Portland EIS, (Alcoa & Kinhill Planners, 1980) the Tomago EIS, (Croft and Associates, 1980) and the Lochin-

var EIS (Alumax/Dames and Moore, 1980):

- proximity of area to long-term supplies of reasonable cost electrical energy;
- proximity of area to supplies of alumina;
- proximity of area to the product market (or easy transport to it, e.g. a port);
- proximity to shipping and bulk unloading facilities;
- availability of a site which is acceptable on environmental, technical (engineering) and social grounds;
- suitable transport infrastructure;
- sources of construction labour; and
- reliable workforce.

Once the regional criteria have been considered, the site specific requirements can be addressed. Consideration by the Authority of these regional criteria suggests that in the case of a Western Australian smelter the most probable location for a smelter would be in the South West of the State, close to raw materials, energy supplies and port facilities.

3.1.5 SITE SPECIFIC REQUIREMENTS

The requirements for a smelter site that are of relevance to the Authority fall into two categories, namely environmental and social considerations. These are listed below:

Environmental considerations — Impacts on the environment:

- solid waste disposal;
- biological significance — in particular any effects on conservation significance of the site;
- landscape — visual impact of development;
- wastewater disposal — extent of constraints on wastewater disposal;
- potential air emissions impact — sensitivity of surrounding land uses to air emissions; and
- noise pollution.

Social considerations — Impacts on people:

- community infrastructure/social impact — ability of existing community(ies) to absorb increased population;
- local amenity/future land use options — effects on existing and potential future land uses; and
- where achievable, identification of procedures needed to minimise any negative social impacts.

In addition there are environmental aspects to take into account in other areas, for example the engineering criteria for a smelter indicate that suitable topography and soil conditions are needed, and also that the smelter platform is adequately separated from groundwater. There are environmental implications of these criteria.

3.2 REGIONAL ENVIRONMENT

The proponent has reviewed potential sites within a region broadly bounded by Mandurah and Pinjarra in the north, Collie to the east and Busselton in the south. This region has been identified in the ERMP as the regional location that offers the most significant and relevant advantages to the establishment of an aluminium smelter (Helleman, Section 3.2).

The following description of this region is based, in part, on information contained in the 'Atlas of Natural Resources, Darling System, Western Australia' (Department of Conservation and Environment, 1980a).

3.2.1 GEOLOGY AND GEOMORPHOLOGY

There are two distinct geological provinces in the South West of the State. These provinces are separated by the Darling Fault. East of the Fault is the Yilgarn Block*, a relatively stable shield composed of Archaean* rocks. The other province is the Perth Basin, which consists of a deep trough filled with Phanerozoic* sedimentary rocks. These provinces are generally termed the Darling Plateau (of which the Darling Range is the most western component) and the Swan Coastal Plain. The Kemerton area lies on the latter.

The Swan Coastal Plain consists of a sequence of aeolian deposits* which have formed three main dune systems. The oldest are the Bassendean Dunes, followed by the Spearwood Dunes and then the most recent, the Quindalup Dunes along the present coast. Each of these can be classified on the basis of erosional modifications and the presence of swamps. To the east of the Bassendean Dunes are alluvial soils, including the Guildford Formation. These alluvial soils are generally referred to as the Pinjarra Plain. Further discussion of the soil divisions is given in Section 4.2.3.

A series of major wetlands is present on the coastal plain. Several, such as Peel Inlet, Harvey Estuary and Leschenault Inlet, are connected to the sea, while other lakes, including Lake Preston and Lake Clifton, are located in inter-dunal depressions. The generally shallow water table causes much of the Coastal Plain to be seasonally wet through surface exposure of the groundwater.

3.2.2 VEGETATION

Jarrah (*Eucalyptus marginata*) and marri (*E. calophylla*) are the dominant vegetation types of the Darling Range. They form an open-forest system.

The vegetation of the coastal plain ranges from areas of open forest of jarrah, marri and tuart (*E. gomphocephala*) through wetland complexes, usually dominated by *Melaleuca* and *Banksia* species to low heaths and sedgelands.

3.2.3 CLIMATE

The region experiences a Mediterranean climate*, with hot dry summers and mild wet winters. Most of the seasonal rainfall pattern results from the progress of sub-tropical low systems from the Indian Ocean. Strong winds generally prevail for most of the year, with the predominant directions being from the south and west.

3.2.4 POPULATION

The South West Region contains a substantial portion of the population of the State. Population within the area between Mandurah and Busselton is generally concentrated in settlements, with Bunbury and Mandurah being dominant. Smaller centres are Pinjarra, Waroona, Harvey, Capel and Busselton.

3.2.5 ECONOMY

Agriculture has been the basis of economic activity in the region for almost one hundred years. Recent mineral development has generally not affected agricultural activity but has significantly broadened the economic and employment base. An increasing portion of the employment opportunities in the region occur within service industry sectors.

3.3 ALTERNATIVE LOCATIONS CONSIDERED FOR THE ALUMINIUM SMELTER

3.3.1 SITES CONSIDERED BY THE PROPONENT

Fourteen possible locations for the aluminium smelter were initially selected by the proponent, following an aerial reconnaissance survey in the South West. Criteria used to select the sites were:

- apparent topographic suitability;
- spatial relationship with surrounding land uses and activities.

The fourteen sites were:

- Lake Clifton East (site A)
- Lake Preston East (site B)
- Binningup North (site C)
- Kemerton (site D)
- Bunbury East (sites E and F)
- Minninup (site G)
- Capel South (site H)
- Worsley Siding (site I)
- Collie East (site J)
- Roelands East (site K)
- Harvey South (site L)
- Wagerup (site M)
- Pinjarra (sites N)

Twelve of these sites were considered in the ERMP and are shown in Figure 5, (sites A to L). Two additional sites (sites M and N) are addressed in Section 3.3.2. A brief description of each site is given in Appendix F.

All the sites are on the coastal plain except for sites I, J and K which are Darling Range sites.

3.3.2 PINJARRA AND WAGERUP SITES

In the Notice of Intent submitted to the Authority by the proponent in January 1984, two additional sites, Pinjarra and Wagerup, were included. Site M was in proximity to the alumina refinery at Wagerup and Site N (two sites) adjacent to the alumina refinery at Pinjarra.

The proponent did not address these sites in the ERMP. The Authority understands that modelling air emissions from these sites would be extremely difficult.

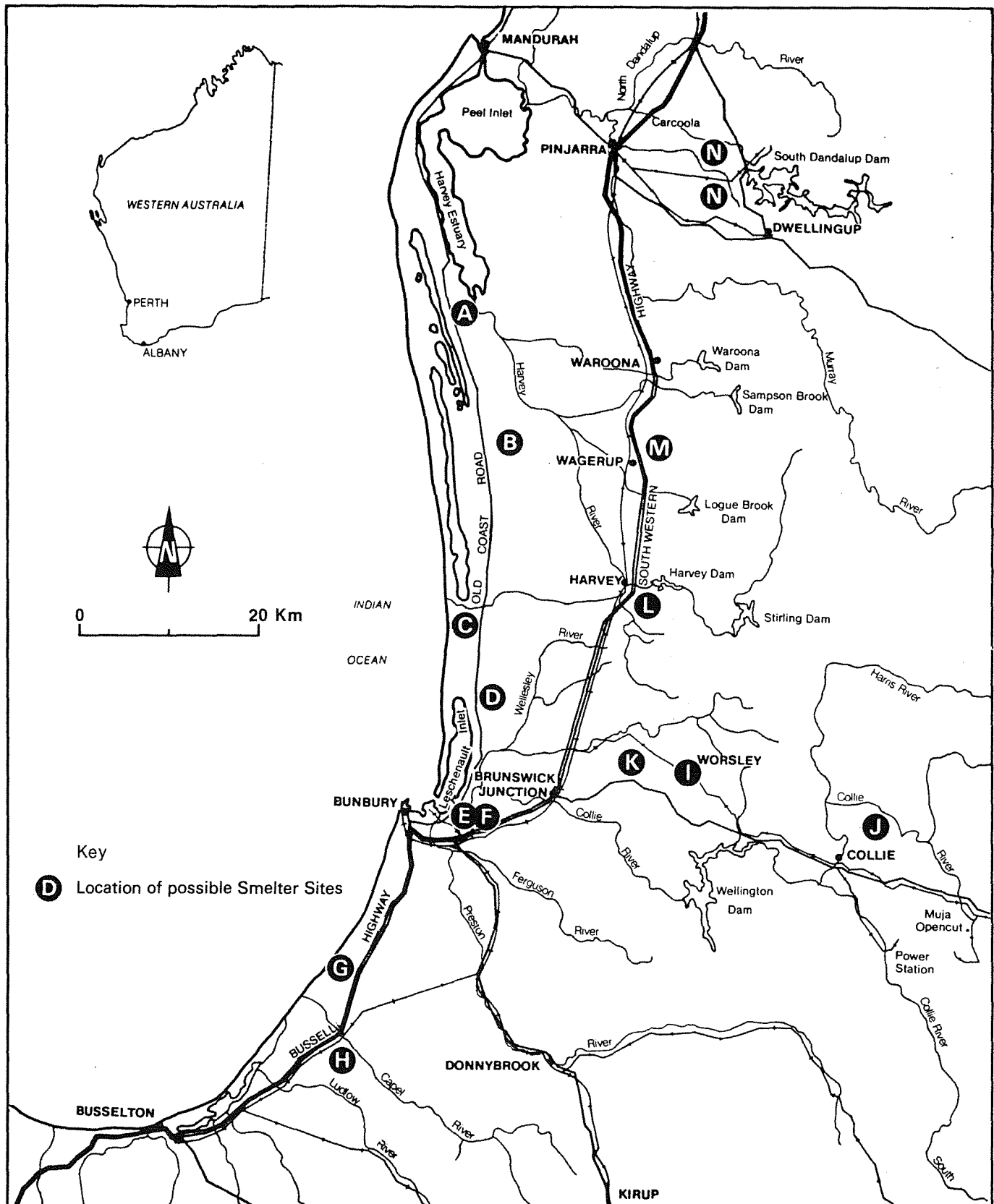


Figure 5 — Locations of Alternative Smelter Sites Considered by the Proponent.

Source: ERMP

3.3.3 PROPONENT'S REVIEW OF THE SITES

It is the view of the proponent, as expressed in the ERMP, that either Kemerton or Worsley Siding could support the establishment of an aluminium smelter on the basis of its assessment of the two sites. However, as explained in Section 3.5 of the ERMP, the Kemerton area, as proposed by the Government, "offered advantages over both the existing conditions at Kemerton, and the existing and probable future conditions at Worsley Siding" (Helleman, p3-17). As a consequence, the Kemerton area has been adopted by the proponent as the proposed site.

3.3.4 EVALUATION OF WORSLEY SIDING AND KEMERTON

The following discussion briefly reviews the two sites considered in the ERMP.

The Worsley Siding site is located on private land within the Darling Range, approximately 13km west of Collie. The site, approximately 365 hectares in area, has been partly cleared and is surrounded by State Forest. It lies within the catchments of the Wellington Dam and the Brunswick River and contains gently undulating ridges and valleys. A range of infrastructure components, including railway, road and transmission lines, are located in the immediate vicinity of the site.

The Kemerton area is located approximately 15km north of Bunbury. It consists of private land that has been partially cleared for agriculture and is surrounded by rural land. More detail concerning this site is given in Chapter 4 of this Assessment Report.

The Authority believes that, in terms of a broad comparison of these two sites, there are significant differences between Worsley Siding and Kemerton. A number of these are briefly described below:

Worsley Siding

- the potential impact of fluoride on the forest ecosystem is uncertain and largely unknown. Interactions within the ecosystem are diverse and poorly understood making predictions hazardous. The stress of fluoride would be additional to the existing stresses of dieback, bushfires, disease infestation, salinity, etc. and sulphur dioxide from the Worsley alumina refinery on the jarrah forest. At low concentrations sulphur dioxide and hydrogen fluoride can have detrimental synergistic* effects on vegetation;
- the area is species rich with considerable plant and animal diversity and a high degree of endemism*. There is a risk of significant loss of important conservation resources, not only of the forest itself, but also of ecologically valuable river valleys;
- the site is located within the catchments of the Wellington Dam, which is used for irrigation and potable supplies, and the Brunswick River, which has potential for water supply development. The alteration of vegetation patterns and the requirements of contaminated liquid and solid waste disposal may result in an impact on these water resources;

Kemerton

- in the nearby pasture areas, the fallout of fluoride would be minimal compared with the dosing they receive annually through phosphate fertilisers which contain up to 4-5% fluoride. Fluoride would be likely to have little effect on dairy cattle grazing on these pastures because of the distance from the smelter, and because the pasture is irrigated. The effect may only be significant if pastures are close to the smelter and are allowed to dry out in summer. Furthermore lucerne, which is grown in the area and is a stock feed, is tolerant of fluoride and most clovers are intermediate in sensitivity to foliar necrosis*. The prediction and monitoring of these effects is straightforward;
- there is little likelihood that fluoride would have a detrimental effect on dairying. The mechanisms through which any detrimental effects operate are well known and appropriate management measures are available to ameliorate any adverse effects;
- the potential impact on nearby wetlands is better understood, and hence could be minimised with appropriate management; and
- much of the vegetation on site is regrowth and would be replaced by pine plantations (Forests Department, 1985).

3.3.5 CONCLUSION

The EPA proposed Kemerton and Worsley Siding as prospective sites for a smelter. The Authority has confined itself in this Assessment Report to an evaluation of these two sites and a comparison of them on environmental grounds has led the Authority to the conclusion that Kemerton is a more appropriate location for an aluminium smelter because of:

- fewer uncertainties of ecological interactions;
- much better knowledge of potential impacts;
- lower environmental risk.

RECOMMENDATION 1:

The EPA recommends that the Worsley Siding site is an environmentally unsuitable site for an aluminium smelter.

4. EXISTING ENVIRONMENT AT KEMERTON

4.1 ENVIRONMENTAL HISTORY

The Harvey district was first settled in the 1840s but development was slow because of poor soils, inadequate drainage, lack of transport and a lack of capital necessary for the costly task of land clearing.

It was not until the 1890s, following the building of the Perth-Bunbury railway, that any significant development occurred. In 1895 the Harvey townsite was established as the region's commercial and administrative centre.

The rapid growth of the timber industry between 1890 and 1930 led to the widespread destruction of vast areas of native forests. In addition, successive governments, through land settlement policies, encouraged settlers to carry out extensive clearing on their holdings. This resulted in approximately 70% of the scarp and foothills being cleared and the virtual total clearing of the alluvial soils between the scarp and the infertile soils closer to the coast.

After 1930 the timber industry gradually declined in importance in the district and today it is confined to small selected areas of State Forest with mills at Yarloop and Waroona.

As the timber industry declined agriculture expanded and so the district continued to prosper. World War II saw an expanding metropolitan market which, in turn, consolidated agricultural development in the district, particularly in dairying, which resulted in the further development of the small towns of Brunswick Junction, Benger, Wokalup, Yarloop and Cookernup. The areas closer to the coast on very infertile sands remained largely undeveloped.

Today the Harvey district is of major importance for the production of dairy cattle, whole milk and beef cattle and irrigated pastures developed on the alluvial soils.

More recently, the trend towards hobby farms has penetrated the region and several Special Rural Zone subdivisions now exist. This has resulted in a broadening of the types of residential areas and rural land uses available in the region.

4.2 BIOPHYSICAL ENVIRONMENT

This section briefly describes the biological and physical environmental characteristics of the proposed smelter site and associated proposed Government-owned buffer zone.

4.2.1 CLIMATE AND METEOROLOGY

The area has a Mediterranean climate, with wet, mild winters and hot, dry summers. The long-term mean annual rainfall at Bunbury is 875 mm, most of which falls between May and October. Annual pan evaporation is about 1900 mm, and evaporation exceeds rainfall between October and May.

The wind climate and other meteorological data from the smelter site have been monitored by Alcoa at Kemerton, and this record has been supplemented by detailed measurements from Glen Iris, near Bunbury. A full comparative analysis of these data is given in Department of Conservation and Environment (DCE) Bulletin 203, 'Dispersion Modelling of a Proposed Aluminium Smelter at Kemerton, Western Australia'.

The summer wind pattern is dominated by the local sea breeze-land breeze system, with light south-easterlies (which are the dominant winds) in the early morning and at night, followed by stronger south-westerlies during the day.

The winter wind pattern is dominated by the eastward progression of synoptic systems (cold fronts), with rain-bearing depressions and north-westerly storms, resulting in more variable winds. Annual wind roses are given in Department of Conservation and Environment Bulletin 203.

4.2.2 HYDROLOGY AND WATER RESOURCES

4.2.2.1 Surface Water Resources

The surface water resources of the proposed smelter site and buffer zone, and the water level contours of the surficial aquifer are shown in Figure 6.

The Wellesley River to the east of the site is a tributary of the Brunswick River, which flows to Leschenault Inlet. The Wellesley River flows all year round supplemented in summer by discharge irrigation water. Peak flows occur in winter and early spring.

The Brunswick River downstream of Brunswick Junction, and the Wellesley River from about 1 km north of the Wellesley Road Bridge are the subject of a System 6 recommendation because of their high conservation values and proximity to populated areas (Environmental Protection Authority, 1983).

There are several permanent and ephemeral lakes and swamps to the north and south-east of the site, known collectively as the Kemerton wetlands.

These wetlands are surface expressions of the surficial unconfined aquifers on the site. Although many have been degraded by agricultural land clearing, encroachment by stock and

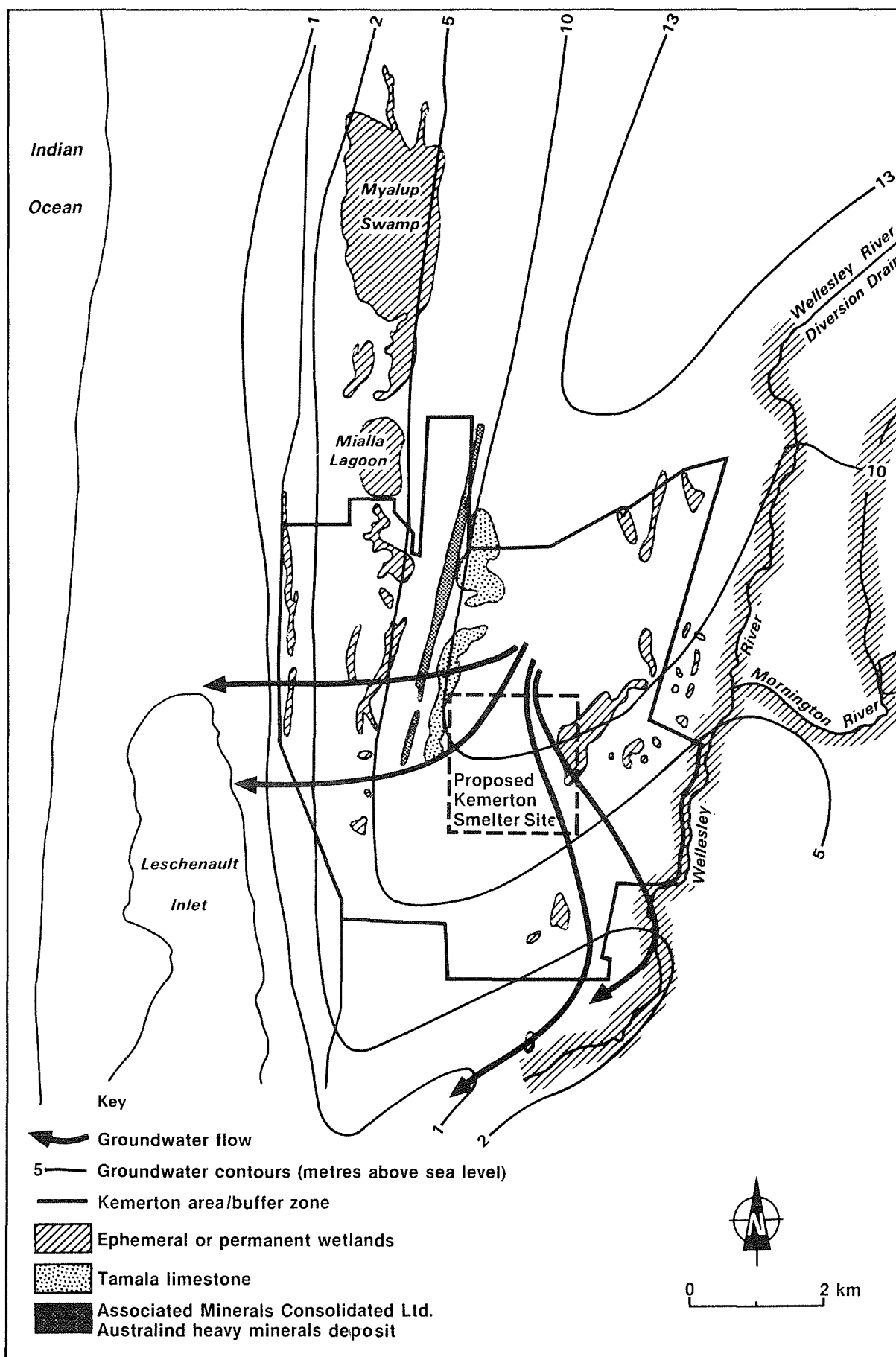


Figure 6 — Surficial Watertable Contours, Inferred Directions of Groundwater Flow and Mineral Resources of the Kemerton Area. (Adapted from Geological Survey W.A., 1985).

fertiliser-enriched water, they are considered to be of high conservation value, and an important wildlife refuge (Helleman, 1985; Bunn, 1982).

The Kemerton wetlands also support a diverse wetland flora.

4.2.2.2 Groundwater Resources

The regional groundwater system has been generally described by Sanders (1974), Commander (1982) and by the Geological Survey of W.A. (1985).

The groundwater contours of the surficial aquifers of the Bassendean and Karrakatta Sands are shown in Figure 6. A groundwater divide running north-east to south-west roughly bisects the site. On the western side of this divide, groundwater flows west towards Leschenault Inlet and the sea, some of it via the western Kemerton wetlands.

To the east of the divide, groundwater flows towards the Wellesley River, some of it via the south-eastern wetlands.

The sands containing the surficial aquifer are fairly permeable, and groundwater flows are probably of the order of 15 to 50 metres per year (Helleman). Other estimates suggest that groundwater flows are in the order of 50-100 metres per year (Section 7.2.2.3). Field confirmation of the groundwater flows would be advisable.

From a soil survey of the Kemerton area Dimmock (1985) determined that the water-table in the Bassendean Sands occurs on average at about 2 m depth in summer, though it is considerably less than this for the low-lying Joel series soils (Appendix B). The water-table rises following winter rains and progressively falls during summer and autumn, reflecting the markedly seasonal rainfall regime. The water-table of the surficial aquifer in the Bassendean Sand is often marked by a dark, cemented organic hard pan known as 'coffee rock', although the water-table is not perched on the 'coffee rock'.

The salinity of the unconfined groundwater is variable, mostly in the range of 500-1000 milligrams per litre (mg/L) and high levels of iron and carbonate (Commander, 1982).

The unconfined aquifer may leak downwards to the semi-confined aquifers of the Leederville and Yarragadee Formations (Figure 7), and there may be some localised upward leakage of the Leederville Formation groundwater into the unconfined aquifer.

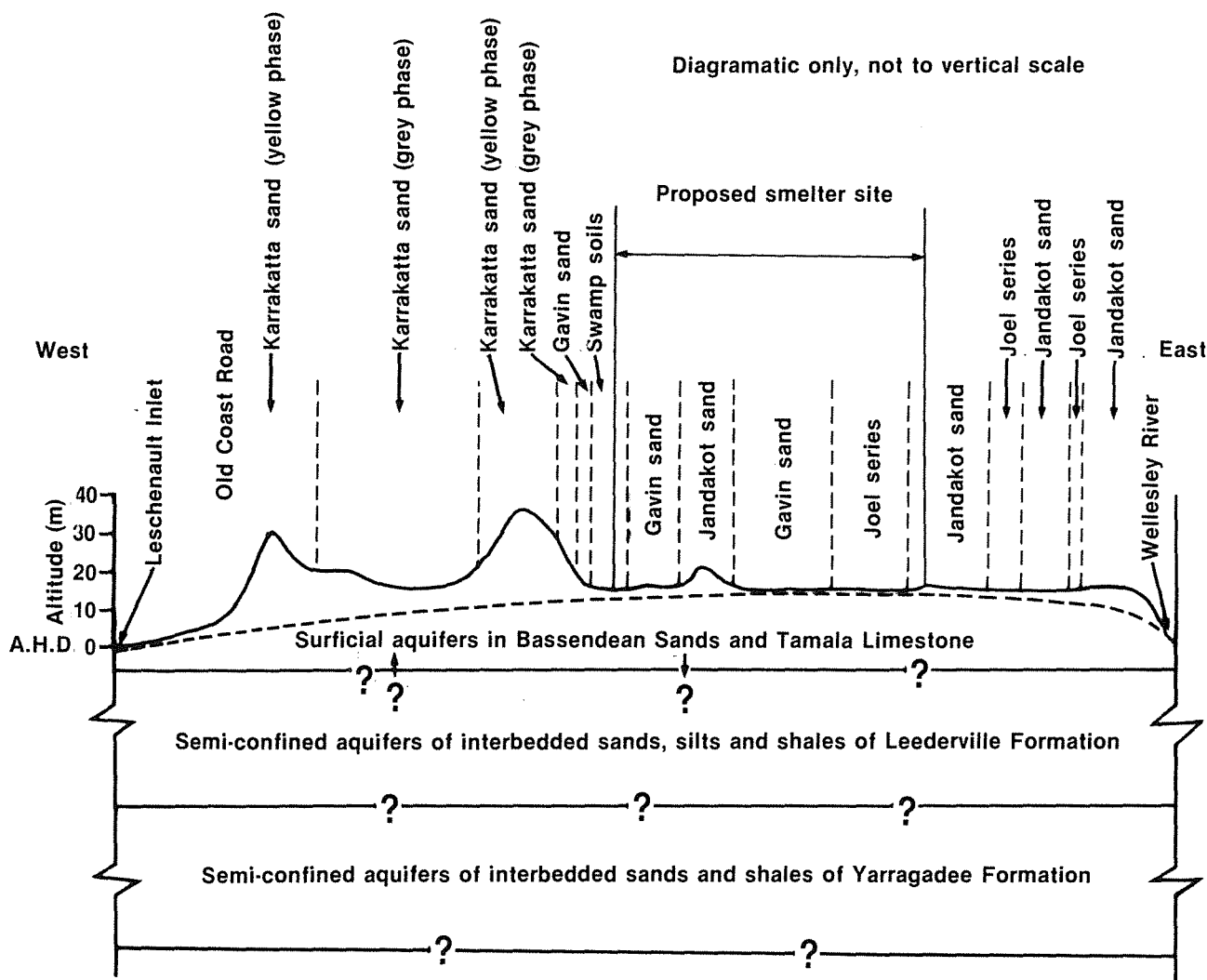


Figure 7 — W-E Cross Section from Leschenault Inlet to Wellesley River via part of Marriott Road. (Adapted from Dimmock, 1985).

The salinity of the Leederville Formation groundwater is about 1000-1200 mg/L, and the concentrations of iron and other dissolved minerals tend to increase with depth. Both semi-confined groundwater sources are exploited for urban agricultural and industrial use in the wider region, and low-yield bores tap the surficial aquifers for irrigation water (Geological Survey WA, 1982).

The groundwater resources of the site are within the South West Coastal Groundwater Area, and groundwater extraction is controlled by the Public Works Department.

4.2.3 GEOLOGY, SOILS AND LANDFORMS

The Kemerton site is on the western edge of the Swan Coastal Plain, the soils of which have resulted from marine, riverine or aeolian processes. The general regional pattern of soils and landforms has been mapped at a scale of 1:250,000 by Churchward and McArthur (1980). Recent detailed mapping for the site has been carried out by Dimmock (1985). Dimmock's map is reproduced as Figure 8.

The area lies within the Spearwood and Bassendean Dune Systems of the Swan Coastal Plain (McArthur and Bettenay, 1974), and is generally described by Dimmock (1985) as follows:

"The Spearwood System, to the west, consists of a series of sand dunes of rolling topography aligned roughly parallel to the present coastline and reaching an altitude of at least 40 metres. The highest of these dunes tend to be cored with limestone and few scattered outcrops occur within the surveyed area. Occupying a central low-lying belt within the Spearwood System is a chain of permanent wetlands, the largest of which are fringed by narrow terraces, 1 to 2 metres above water level.

The Bassendean Dune System, to the east, forms a gently undulating to easy rolling landscape, in which the dune elements are generally subdued, randomly oriented and seldom more than 20 m above sea-level. Much of the landscape consists of broad very low rises with intervening low-lying poorly-drained areas, particularly in the zone immediately westwards from the Wellesley River where there is an extensive mosaic of seasonal wetlands.

The transition between the two major dune systems is often quite abrupt except where the higher dune elements of the Bassendean System abut the Spearwood System.

The north-western corner of the Kemerton site also includes a small area of Yoongarillup Plain. This occupies generally flat terrain with minor ridges and swales and carries permanent wetlands in the lowest topographic situations."

The major soil types are widely represented on the Swan Coastal Plain and their general characteristics are well known.

The Quaternary* age dune systems lie over sandstones, silts and shales of Cretaceous* age known as the Leederville Formation. These in turn lie over interbedded sands and shales of Jurassic* age known as the Yarragadee Formation.

There are few mineral resources of note, except for a heavy mineral deposit to the north-west of the site (Figure 6). Two limestone deposits in the Spearwood Dune System contain small quarries, one of which is abandoned (Geological Survey of WA, 1982).

The soils of the site have low natural fertility, and studies are currently in progress to determine their ability to fix fluoride (Appendix B).

Dimmock (1985) has mapped five major soil units, each occupying 15-20 per cent of the site, and three minor units. Their distribution on the site is shown in Figure 8 and typical soil profiles are plotted in Figure 9.

The major soil units are Karrakatta sands (yellow and grey phases) of the Spearwood Dune System and the Joel series, Gavin and Jandakot sands of the Bassendean Dune System. The minor units comprise the Yoongarillup Association and two swamp complexes designated Swamp Complex 1 and Swamp Complex 2 of the Spearwood and Bassendean Systems respectively.

4.2.4 VEGETATION

Approximately 40% of the proposed smelter site and surrounding buffer zone has been cleared for agricultural purposes. The remaining native vegetation has been mostly degraded to some extent, but each community retains recognisable remnants of its original structure and species composition (Figure 10).

The native vegetation is closely related to soil type, and its composition and distribution has been described by Dimmock (1985).

The vegetation of the Spearwood Dune System is a eucalypt woodland of two main types:

- tuart (*Eucalyptus gomphocephala*) with an understorey of peppermint (*Agonis flexuosa*) and bull banksia (*Banksia grandis*) occurs on Karrakatta yellow sands.
- jarrah (*E. marginata*) with an understorey dominated by narrow-leaved banksia (*B. attenuata*), holly-leaved banksia *B. ilicifolia*) and woody pear (*Xylomelum occidentale*) occurs on the Karrakatta grey sands.

The Spearwood System wetlands support a fringing woodland of paperbarks (*Melaleuca raphiophylla* and *M. preissiana*), flooded gum (*E. rudis*) and river banksia (*B. littoralis*).

The soils of the Bassendean Dune System support a jarrah-banksia woodland on the higher

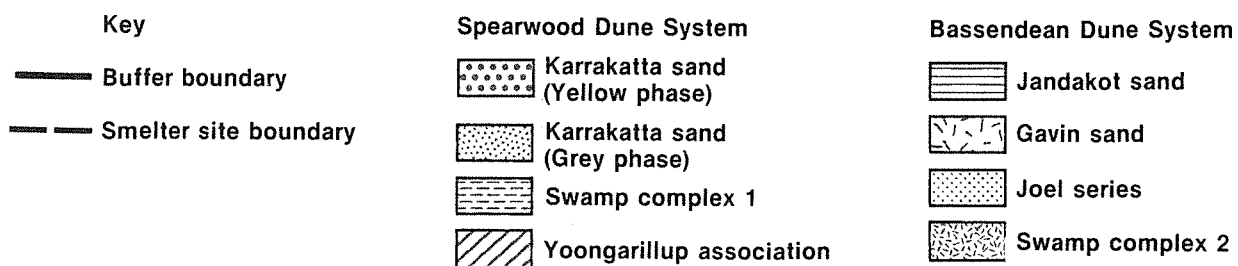
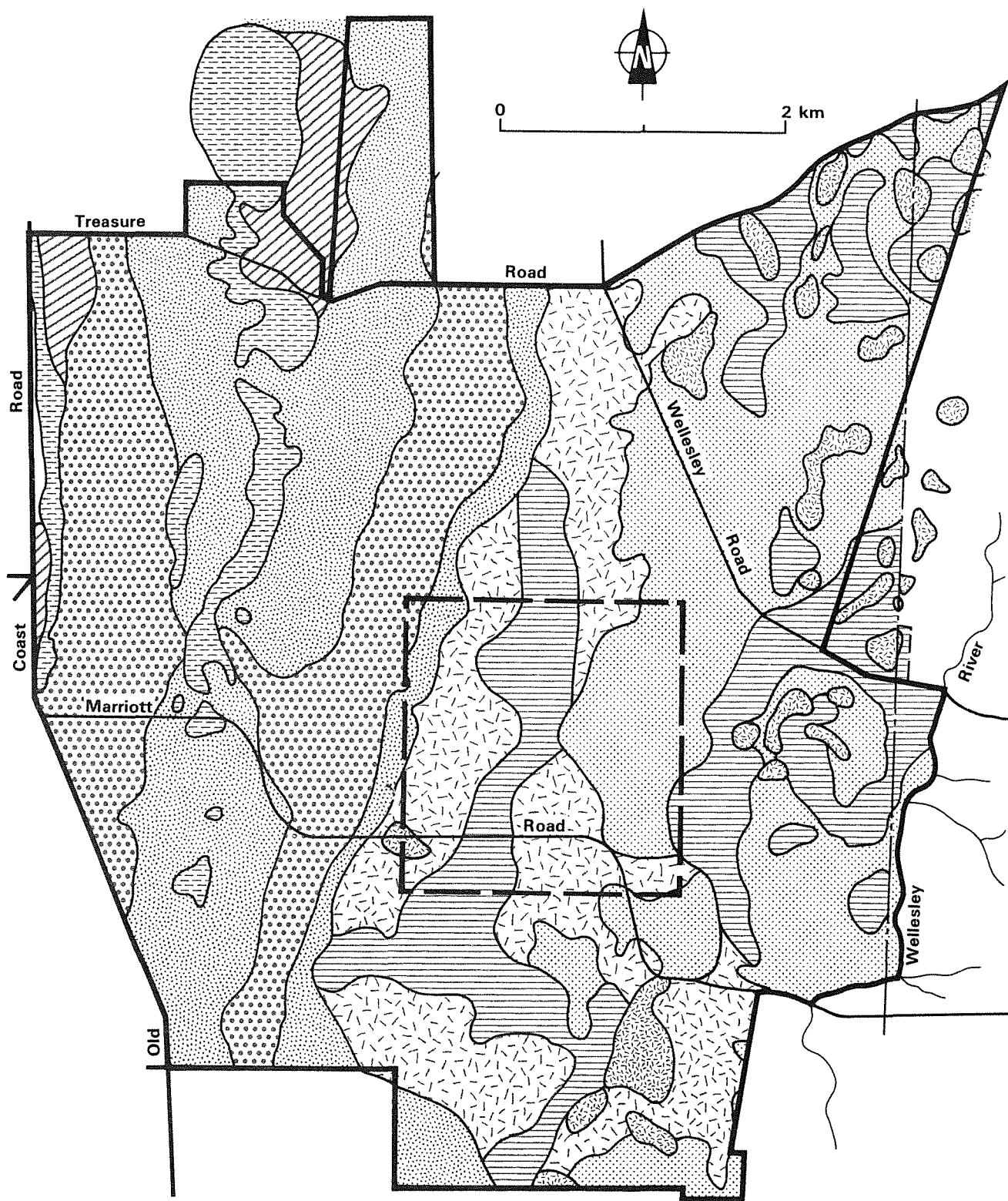


Figure 8 — Soil Units in the Kemerton Area.

sand ridges, while the wetlands have similar vegetation to those of the Spearwood System.

The central areas of most wetlands support dense reedbeds of *Baumea* sp. *Typha* sp. or sedges, though several retain areas of open water. They range from permanent waterbodies to drained swamps which retain surface water for only limited periods. The wetlands, which elsewhere on the Swan Coastal Plain are increasingly being developed for agriculture, contain a range of habitats and are considered to be of conservation importance (Bamford and Watkins, 1983).

In recognition of their conservation and recreation values, the lower reaches of the Wellesley River, Leschenault Inlet, Myalup Swamp and Mialla Lagoon are subject to System 6 recommendations (Environmental Protection Authority, 1983).

Eight plant species with restricted distributions have been recorded from the site, including a population of *Pultenaea skinneri*, recorded from the woodland bordering the south-eastern wetland, which comprises the largest population of this species yet discovered (Weston, 1985).

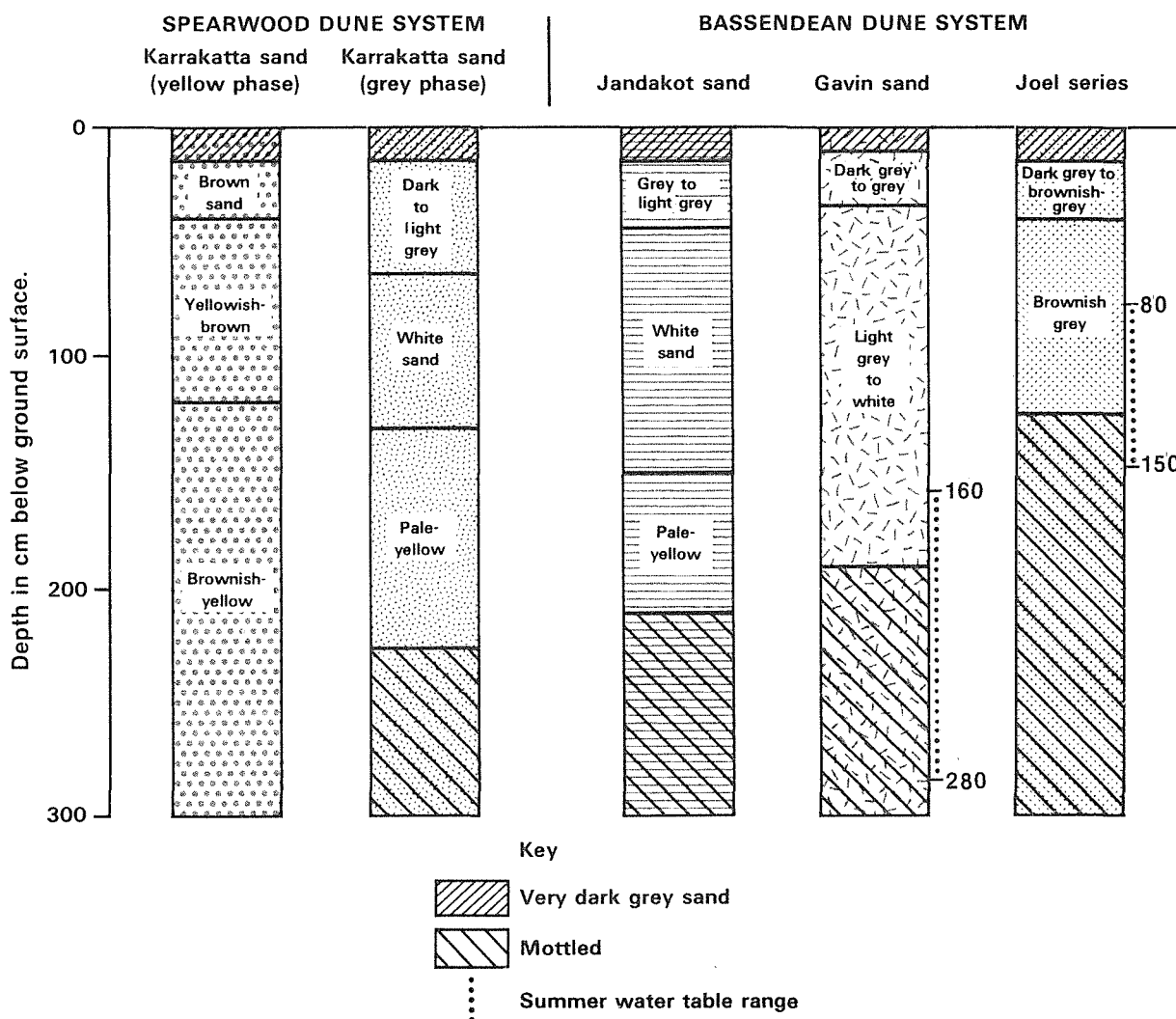


Figure 9 — Generated Profiles of the Major Soil Units, Kemerton Area (source: Dimmock, 1985).

4.2.5 FAUNA

The fauna of the Kemerton site has been surveyed in a limited way by Nichols (1980), Bamford and Watkins (1983) and Bunn (1982).

The surveys of Nichols, Bamford and Watkins concentrated on mammals, birds, reptiles and amphibians, and indicated that the fauna was typical of similar habitats elsewhere on the Swan Coastal Plain. The wetland areas were identified as a regionally important resource for waterbirds.

Bunn surveyed the aquatic invertebrates of the western chain of wetlands. A diverse fauna was found, and there was some indication that seasonal changes of salinity might cause the temporary replacement of typical freshwater species with more salt tolerant forms. The wetlands were sampled only in spring, and more species would probably be detected by additional sampling in winter and late summer.

The wetlands and the less disturbed areas of native terrestrial vegetation are considered by the Authority to be regionally valuable habitats for fauna.



Figure 11 — Existing Land Use

4.3 EXISTING LAND USE

Agricultural pursuits are the dominant land use in the Kemerton area. The ERMP identified the following as the main agricultural practices in the area:

- dairying on irrigated pastures, primarily east of the Wellesley River and west of the Old Coast Road;
- dryland grazing west of the Wellesley River and to the north and west of the site;
- irrigated fodder crops, market gardens and orchards to the west and north-west of the site; and
- irrigated beef cattle grazing on some properties adjacent to the Wellesley River.

The Harvey Shire is recognised as one of the primary dairy areas in Western Australia, contributing approximately one quarter of the State's total milk production. It should be recognised however that the distribution of dairying, as with other agricultural land uses in the Shire of Harvey, is strongly influenced by the distribution of soil types. Dairying is primarily confined to irrigated pastures on alluvial soils east of the Wellesley River.

The infertile Bassendean and Karrakatta Sands, in the Kemerton area, support less intensive dryland grazing land use. Within these soil groups, however, limited areas of summer moist soils provide an extended growing season and in some areas may support perennial pastures. The low agricultural value of these soils is, however, reflected in the high proportion of undeveloped land remaining in the Kemerton area (Figure 11).

Immediately to the west of the Kemerton area, the Yoongarillup Plain, with its good quality shallow groundwater resources, supports irrigated crops, (chiefly lucerne) and market gardening, within broader areas of dryland grazing. The development of more intensive irrigated agriculture on these soils is expanding.

In recent years Special Rural Zone subdivisions have been established to the north and east of the Kemerton area and lie within the Kemerton area, to the west of the smelter site. Two other land uses, the Goodchild abattoir and a piggery, are also located within the Kemerton area, approximately 1.5 to 2 km west of the smelter site. It is understood that the wildlife park and bushland zoo located on Wellesley Road east of the Kemerton area has recently closed.

Figure 11 shows the extent of the various types of agricultural land use practised in the Kemerton area and reflects some changes that have occurred since Figure 5.8 in the ERMP was prepared.

Agriculture's importance in the region is declining relative to other industries, but not in absolute terms. It is changing from lower value to higher value enterprises (e.g. from grazing to crops). Although the greater Bunbury region is undergoing transition from a predominantly agricultural economic base to one more dependent on secondary industry, agriculture still constitutes the major land use in the Harvey Shire. Its preservation is of prime concern to the Shire, as indicated by its planning policies and provisions relating to agricultural areas.

The relative significance of agricultural land uses in the Harvey Shire and the extent to which the Shire contributes to the State's total production is illustrated in Table 2. The Table clearly shows the major importance of the dairying industry in the Shire. It should be recognised, however, that much of this production originates in more productive irrigated lands and is not representative of the lands in the Kemerton area.

4.4 EXISTING REGIONAL SOCIAL ENVIRONMENT

The existing social environment of the region in which the smelter is proposed to be located has been described in the Community Needs Study commissioned by the WA Government and co-ordinated by the Department of Resources Development (Dames and Moore, 1985b). This Study was prepared to redress, in part, the inadequacies of the ERMP in the provision of social information. The Study focused on two areas of interest, one encompassing the area within 60 km or 40 minutes travelling time of the smelter site and the other encompassing the local communities in the southern half of the Shire of Harvey. These areas exhibit some differences in land use and settlement patterns.

Bunbury is the largest urban area beyond metropolitan Perth and dominates the region. Population growth is being generated by initiatives in the Bunbury region and is occurring largely beyond the municipal boundaries of the City of Bunbury, in particular in the nearby townships of Australind and Eaton (Figure 12). The younger population age structures in these urban centres reflects the rapid population growth experienced there over the last fifteen years. By comparison, the Harvey township and rural areas of the Shire appear to have lost population since 1976.

The regional economy, and consequently the employment structure of the region, is presently undergoing a transition from a predominantly agricultural base to one which is increasingly dependent on secondary and service industries. The importance of the retail/wholesale, community services, manufacturing and construction sectors in the City of Bunbury is evident, with nearly 60 per cent of the City's workforce engaged in these sectors. In the Shire of Harvey, agriculture and manufacturing each employ 20 per cent of the workforce reflecting the urban/rural split of the Shire's population.

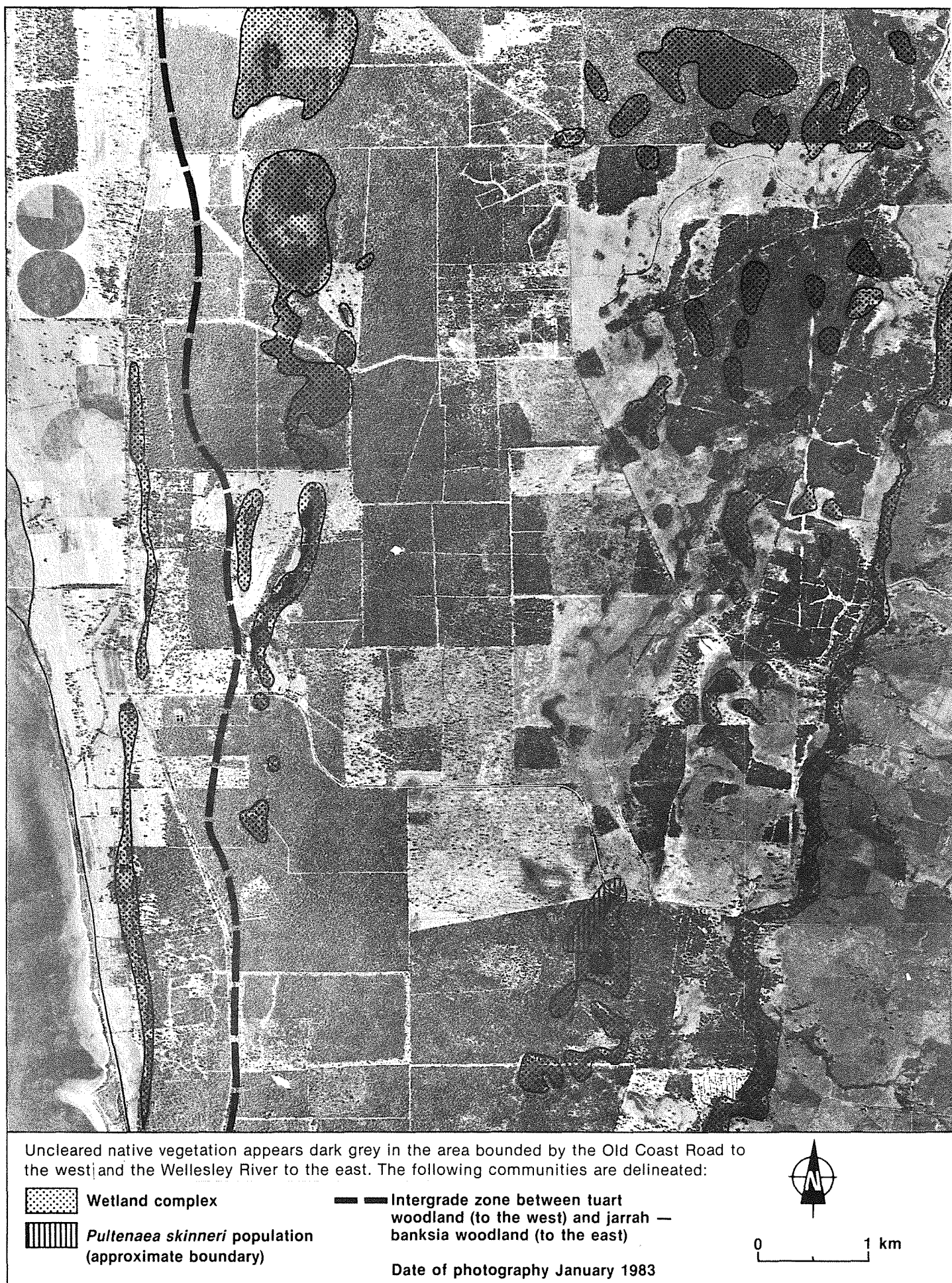


Figure 10 — Native Vegetation Communities, Kemerton Area.

Table 2 Agricultural Statistics — Shire of Harvey (on 31 March or for Year ended 31 March)

	1979		1984	
		(% of State)		(% of State)
LIVESTOCK	(in thousands)		(in thousands)	
Cattle for meat production	36.0	(1.8)	29.4	(1.8)
Cattle for milk production	31.4	(24.5)	31.8	(25.7)
Sheep	25.2	(0.1)	41.4	(0.1)
Pigs	1.7	N/A	N/A	N/A
CROPS	(in hectares)		(in hectares)	
Vegetables for human consumption	283	5.0	296	N/A
Lucerne	498	5.2	1073	N/A
Other crops (a)	472	N/A	624	N/A
Fruit trees (b)	100	N/A	111	N/A
PASTURES excluding	(in thousands of hectares)			
Lucerne	59.7		56.8	
Total area of holdings	77.8		N/A	
Total area of establishments	N/A		77.2	
Area of cleared land	N/A		68.6	

(a) Excludes vegetables, lucerne, and fruit trees.

(b) Fruit trees assumed to be planted at 257 trees per hectare.

N/A Not Available.

Source: Australian Bureau of Statistics.

Analysis of the regional housing market indicates an adequate supply of traditional housing (i.e. single-family houses on standard blocks) but the housing market for home buyers has been relatively stagnant over the last few years. There appears to be a ready supply of serviced residential land with the potential for further development at relatively short notice. The rental housing market in the City of Bunbury is experiencing some restrictions at present attributed to the sale of rental properties to home-owners in the wake of completion of the Worsley refinery and the associated in-migration of temporary workers. Housing and rental costs are generally lower in the Harvey township because of lower demand.

Within the City of Bunbury, there is a wide range of education, health, welfare and recreation facilities and/or services. Many of these resources serve regional needs and, with some exceptions in the field of education facilities, are adequate for current needs. Education and health resources for children are already under pressure, particularly in the rapidly growing urban centres of Australind and Eaton.

The existing community structure within the region reflects both the well-established farming communities with a strong sense of local pride and identity, as well as the more urbanised and perhaps less socially coherent communities in urban areas such as Bunbury, Australind and Eaton.

4.5 REGIONAL PLANNING CONSIDERATIONS

The purpose of this section is to review the prevailing strategic planning framework as it relates to the Kemerton area. The principal elements of this framework are:

- the Bunbury Region Plan (BRP);
- the South West Development Authority (SWDA) Bunbury 2000 programme; and
- the Shire of Harvey Town Planning Scheme (TPS) No. 10.

Additionally, although not an integral part of the strategic planning framework, the following matters also require consideration:

- the Conceptual Land Management Plan — Kemerton Area, prepared by the Forests Department; and
- the System 6 Study (Environmental Protection Authority, 1983)

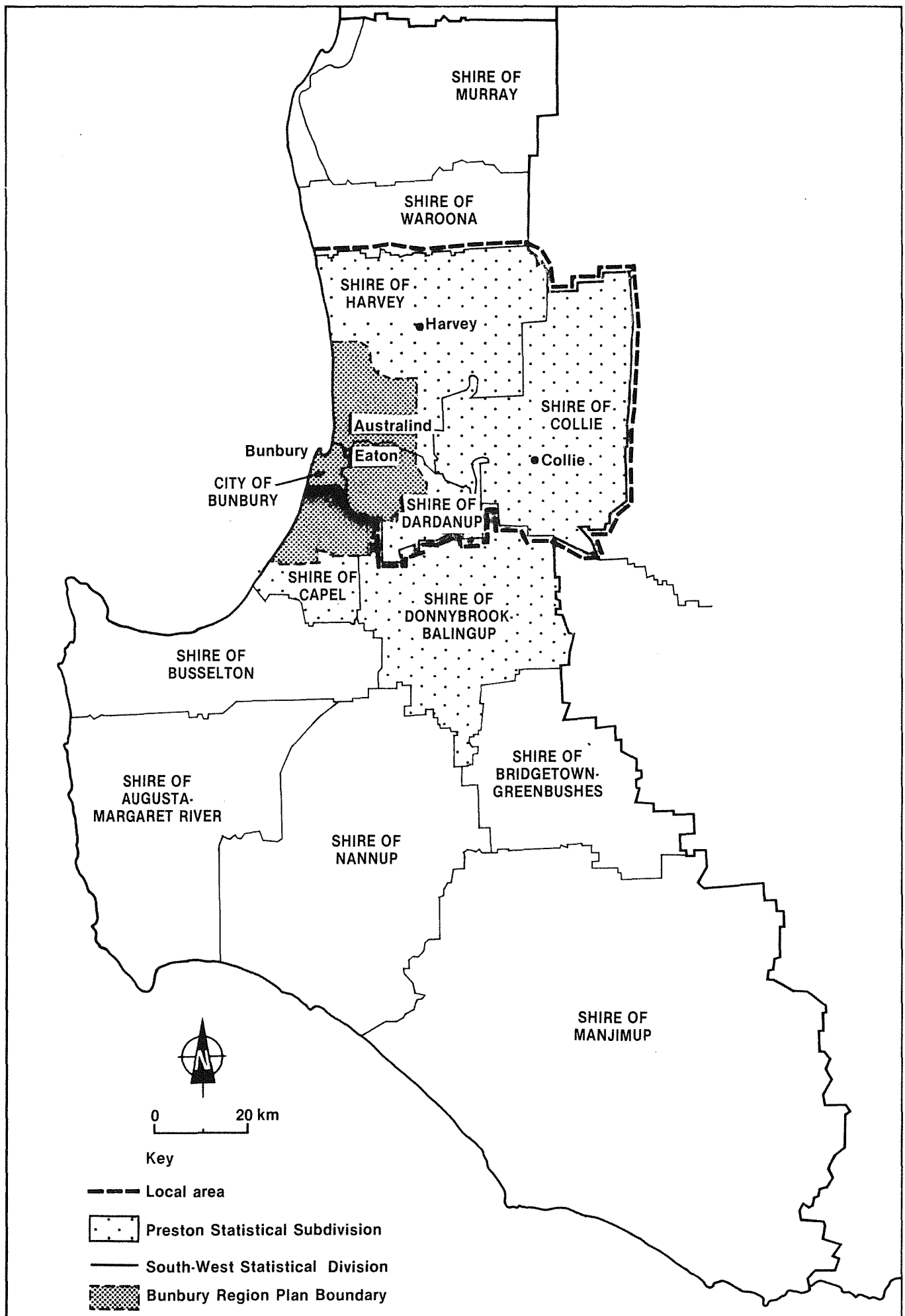


Figure 12 — Figure Showing SW Statistical Area, Local Authorities, and Bunbury Region Plan Boundary.

4.5.1 THE BUNBURY REGION PLAN (See Figure 12)

This is a non-statutory land use plan for the near-Bunbury region, and has been adopted in principle by the present State Government. The Plan assumes major growth in the secondary and processing industrial sectors and consequently allocates considerable areas to industrial uses. These are concentrated around the harbour and in the Picton Junction and Davenport localities.

The pattern of industrial areas established by the BRP acknowledges the need for adequate separation between industrial and residential areas and is premised on the concept of buffers based on the classification of activity according to its potential to adversely affect adjoining areas.

Although lying in the general path of long-term residential expansion of Australind, the Kemerton area remains as rural land under the BRP.

4.5.2 BUNBURY 2000 PROGRAMME

The programme promotes development within the South West Region and reinforcement of Bunbury as the regional service centre. The SWDA is seen as a facilitator of development and the programme identifies a number of key industries in which it will become involved in this capacity. These include the proposed aluminium smelter.

Notwithstanding the clear development orientation of the Bunbury 2000 programme and frequent reference in it to the "Bunbury 2000 plan", the programme does not address land use planning implications of the proposed smelter or place it and the BRP in any sort of context.

4.5.3 SHIRE OF HARVEY TOWN PLANNING SCHEME No. 10

TPS No. 10 is the Shire of Harvey's District Zoning Scheme and is the Council's principal land use planning and development control mechanism.

The Scheme establishes various objects and policies that provide the context for implementation of the specific land use and development control provisions for the different land use zones it creates. TPS No. 10 is the planning mechanism by which that part of the BRP within the Shire of Harvey could be implemented.

The Kemerton area is zoned "General Farming" under TPS No. 10. This reflects the rural designation of the area under the BRP. The underlying policy for the General Farming zone is:

"Council intends to encourage these areas to continue to be used for viable large scale farming activity. Some limited tourist and recreational activity may be permitted where the effect of such development can be contained." (Shire of Harvey, 1983)

The particular provisions for the General Farming zone would not enable establishment of the proposed smelter at the Kemerton site. Accordingly, TPS No. 10 would need to be amended to provide for the smelter. The amending process is under way.

The scheme amendment proposes that a 2100 hectare portion of the Kemerton area which has been purchased by the State Government from Alcoa of Australia Ltd be designated under the "Additional Use" provisions of TPS No. 10 so that:

- an aluminium smelter of specified capacity could be established on a site not exceeding 400 hectares therein; and
- the area of immediate impact would be retained and enhanced as a belt of dense vegetation.

This amendment has been exhibited for public comment as is required by the Town Planning Act and, according to the Shire of Harvey, approximately 100 submissions were received. The Shire is still considering the submissions and the amendment process cannot be finalised until the Council has completed this and has forwarded its recommendations to the Minister for Planning.

The "Additional Use" area originally proposed under the amendment does not fully encompass the site preferred by the proponent for the proposed smelter and under-specified the capacity of the smelter. The Shire of Harvey has agreed to modify the amendment to accommodate these matters. It is relevant to note, however, that the Shire of Harvey has reserved the right to discontinue the amending process should it be dissatisfied with the ERMP and the subsequent assessment of the project. The Shire of Harvey's submission on the ERMP (summarised at Section 6.2) may provide an indication of likely Council action in relation to the amendment. The submission concludes that "it would be irresponsible of Council to support this project at this time with so many issues unresolved".

4.5.4 CONCEPTUAL LAND MANAGEMENT PLAN — KEMERTON AREA

The proposal by Government to establish pine plantations in the Kemerton area was a significant influence on selection of the Kemerton smelter site. The plan contains land use proposals for an area of approximately 3600 hectares which contains both the 400 hectare preferred site for the smelter, and the "Additional Use" area proposed under the amendment to the Shire of Harvey's TPS No. 10.

4.5.5 SYSTEM 6 STUDY

Two areas affected by the Kemerton smelter proposal are the subject of System 6 recommendations (Environmental Protection Authority, 1983). The areas are the Myalup Swamp/Mialla Lagoon wetlands, and the Wellesley River. The BRP, TPS No. 10 and the Conceptual Land Management Plan also have implications for these areas (Section 9.1).

4.6 INFRASTRUCTURE

The Kemerton area is located within the Harvey Shire, in rural land approximately 15 km to the north of Bunbury. As Bunbury is the major regional centre, there is a well-established infrastructure network in the vicinity of Kemerton. Figure 13 indicates the location of some of the important infrastructure components. They are discussed in Section 5.3.4 of the ERMP and in the Aluminium Smelter Services Corridor Study (Dames and Moore, 1985a).

4.6.1 TRANSPORT

Although the Kemerton area has four roads either abutting or passing through it, only the Old Coast Road (Bunbury Highway) is a regionally important road of a high standard construction. The other roads are only of local importance, Marriott and Treasure Roads are unsealed and Wellesley Road is surfaced but narrow.

The closest railway to Kemerton, approximately 9 km east of the site, is the South West Main Line, which carries passengers and goods between Perth and Bunbury.

Bunbury is a major port. Sufficient capacity and land exists at Berth No. 2 within the Inner Harbour to satisfy the raw material and product handling requirements of the smelter. This berth is already serviced by rail and road. Long-term regional planning addresses the possible expansion of the harbour.

An airport capable of handling twin-engined turbo-prop aircraft, but not jet aircraft, is located at Bunbury.

4.6.2 COMMUNICATIONS

The Shire of Harvey is served by telephone via underground distribution cables, connected to exchanges located near the main population centres. The main coaxial cable linking Perth and the South West is located adjacent to the South West Main Line railway.

4.6.3 ELECTRICITY

A 132 kV transmission line runs each side of the Wellesley River, approximately 2 km east of the proposed smelter site. The properties in the general area are served by the SECWA's inter-connected grid.

4.6.4 WATER

Only the main settlements are connected to reticulated water supplies, which are derived from a variety of sources. Rural properties depend on rainwater tanks and/or underground sources for potable water.

4.6.5 NATURAL GAS

The Wagerup to Bunbury natural gas pipeline passes through the Kemerton area, approximately 1 km east of the proposed smelter site.

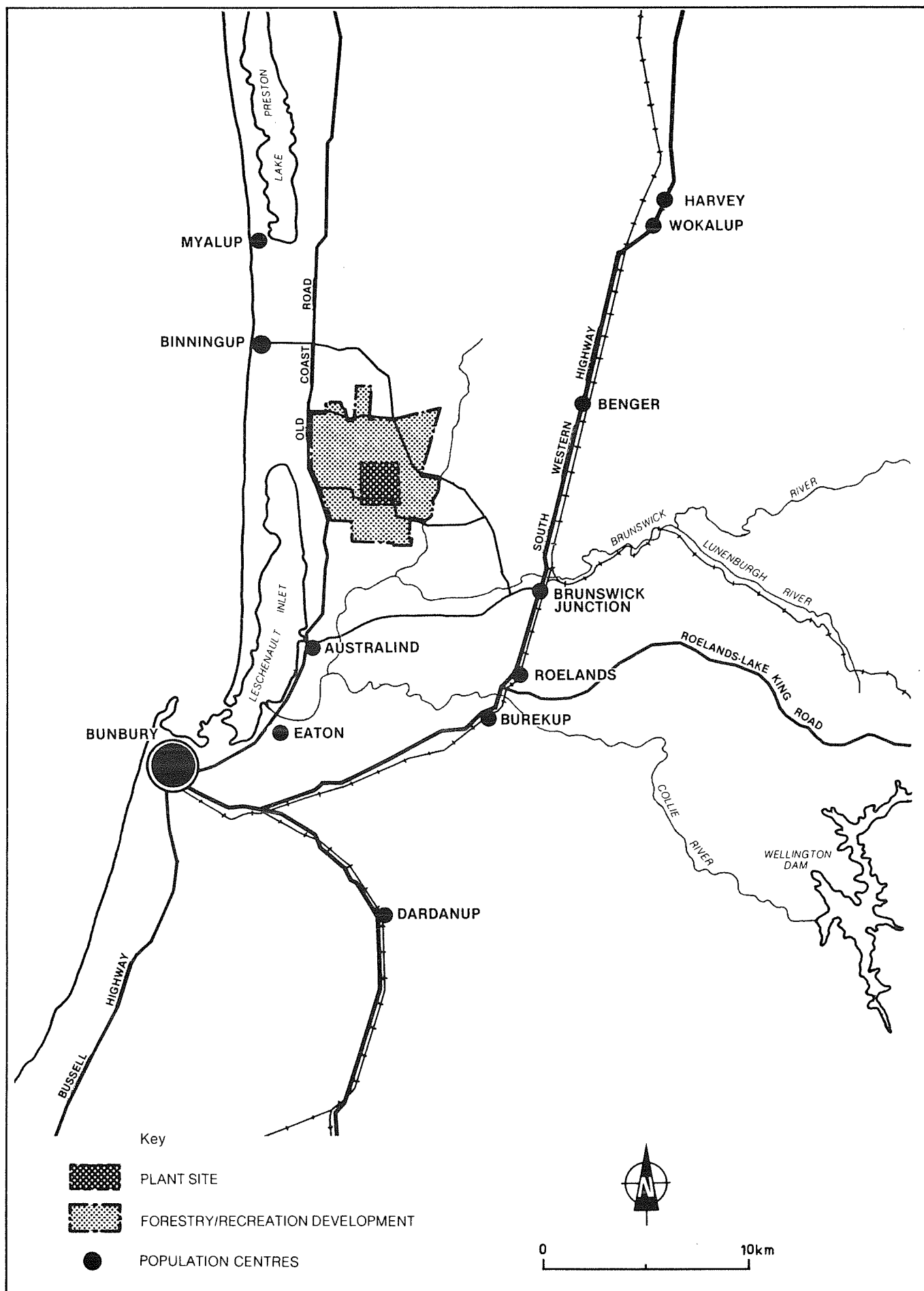


Figure 13 — Regional Location Map and Infrastructure.

5. THE PROPOSAL

The proponent proposes to construct a smelter capable of producing 230 000 tonnes of aluminium per year, using approximately (3.5×10^6 MWh) of electricity.

The smelter would be established on a freehold property of 400 ha, within a larger area of 3600 ha that the Government proposes to progressively acquire and develop for forestry, conservation and recreational purposes.

The smelter would be serviced by a new rail link, two electricity transmission lines; and augmented road and port facilities.

The major raw materials required would be alumina (445 000 tonnes per annum supplied by rail from nearby refineries) and carbon products (117 000 tonnes per annum transported by road or rail from the Port of Bunbury) (Table 3).

Other requirements, as listed on Table 3, include water which is expected to be provided from groundwater sources at the site. This water intake was estimated at 1300 ML per annum in the ERMP but has subsequently been amended by the proponent to approximately 400 ML per annum in the Supplement.

Table 3 Details of Raw Materials and Finished Product.

MATERIAL	SOURCE	CONSUMPTION per annum
Alumina	W A	445000 tonnes
Petroleum Coke	U S A	88000 tonnes
Pitch	N S W	27000 tonnes
Aluminium Fluoride & Cryolite	JAPAN	6000 tonnes
Cathode Carbon	JAPAN, EUROPE	2000 tonnes
Refractories	N S W	700 tonnes
Soda Ash	AUST	300 tonnes
Electricity	W A	3.5×10^6 Mwh
Natural Gas	W A	22×10^6 m3
Liquid Hydrocarbons	W A	600000 L
Water	W A	400-1300 ML

Source: ERMP

5.1 THE PROCESS

5.1.1 ALTERNATIVE TECHNOLOGIES

There are a number of alternative processes to the Hall-Heroult* process which are theoretically possible and currently being investigated including:

- carbothermic* reduction of silico-aluminous ores or of silica and alumina mixtures in an arc-furnace or oxygen blast furnace. These processes can use chlorine and may be non-polluting due to completely enclosed systems and recycling;
- processes involving aluminium in the vapour phase*. This technology employs high temperature, often in an arc plasma;
- carbothermic reduction of alumina in an arc-furnace; and
- Alcoa ASP process (a chlorine-based process).

None of the above-mentioned processes have been undertaken beyond the pilot-plant level. The lead time between research/development and acceptance of an alternative aluminium producing process means that the current Hall-Heroult process would continue to be used until the end of this century.

Although there is little likelihood that a practicable alternative to the Hall-Heroult process will be available before the turn of this century, the Authority expects continuing improvement in pollution control aspects of this process.

5.1.2 THE PROPONENT'S PREFERRED PROCESS

The proponent intends to produce aluminium by the Hall-Heroult process. This involves passing electricity through a molten mixture containing alumina (a compound of aluminium and oxygen) in a bath* of cryolite* and aluminium fluoride.

This reduction process is carried out in vessels called cells or pots. Electricity is passed from a carbon block (anode*) suspended in the molten material, to the lining of the pots (the cathode*), generating liquid aluminium and oxygen. As a consequence of the process, wastes are generated, the most significant of which are fluoride emissions (both gaseous and particulate), sulphur dioxide, spent potlinings, other solid wastes and process water.

The proposed smelter would have 480 pots, distributed between four long buildings known as potrooms. Each pot is capable of producing about 1.5 tonnes of aluminium per day. The interior, sides and bottom of the pots are lined with a refractory material, usually either silica brick or alumina, which becomes contaminated and requires periodic replacement. Hot aluminium metal produced in the pots is vacuum tapped once per day via tapping ladles and is then transferred to the cast house for moulding. For some products, impurities would be removed by reaction with a gas mixture and for other products alloying elements would be added.

Both the anodes and cathodes require periodic replacement. Each pot has a number of anodes (sixteen each at Tomago), and each anode will require replacement within about twenty-four days. The cathodes require replacement after about three to five years, although cathode failure can occur before this time. The proposed plant would have facilities to remove and replace both anodes and cathodes.

New (or "green") anodes are produced in the carbon plant, using petroleum coke, liquid pitch and recycled anode butts. Quantities of the coke and the recycled butts are heated and mixed with liquid pitch and are then formed by a vibrocompactor, prior to baking.

5.2 PLANT LAYOUT AND ORIENTATION

The potrooms contain the major components of the smelter. They are each approximately 800 m long, 20 m wide, and 22 m high. An artist's impression of the proposed smelter has already been shown in Figure 3.

Further facilities to be provided are workshops, warehouses, and administrative buildings. Figure 14 shows the planned layout of the smelter.

The ERMP states that the plant location and orientation of the proposed smelter have been optimised to minimise the effects of fluoride emissions. The four potrooms would run east-west in the south-eastern corner of the property. Figure 15 shows the influence of the plant orientation of dispersion characteristics as presented in the ERMP.

5.3 EMISSIONS TO AIR

The production of aluminium by electrolytic reduction generates atmospheric emissions which include fluorides, other particulates, hydrocarbons, sulphur oxides and carbon oxides. A summary of the major emissions produced is contained in Tables 4 and 5, along with the long-term efficiencies of the collection (scrubbing*) process proposed for the Kemerton smelter.

Table 4 shows that the bulk of the air pollutants produced by the proposed aluminium smelting process would be generated from the pots. The proposed efficiency of the pot hoods (97.5%) would mean that up to 0.8 kg total fluoride per tonne aluminium produced (kg Ft/tAl) could be emitted from the potrooms as secondary emissions*. This is 80% of the total fluorides (as proposed in the ERMP) to be emitted by the smelter. Table 5 shows the efficiency of the proposed scrubbers: 99.5% for the potroom scrubbers and 90% for the anode furnace scrubber. The proposed airborne emissions for these would include 0.16 kg Ft/tAl from the potroom scrubbers and 0.03 kg Ft/tAl from the anode furnace scrubber. The smelter would also discharge a total of 24.8 kilograms of sulphur dioxide for every tonne of aluminium produced.

Further discussion of air emissions is given in Section 7.2.

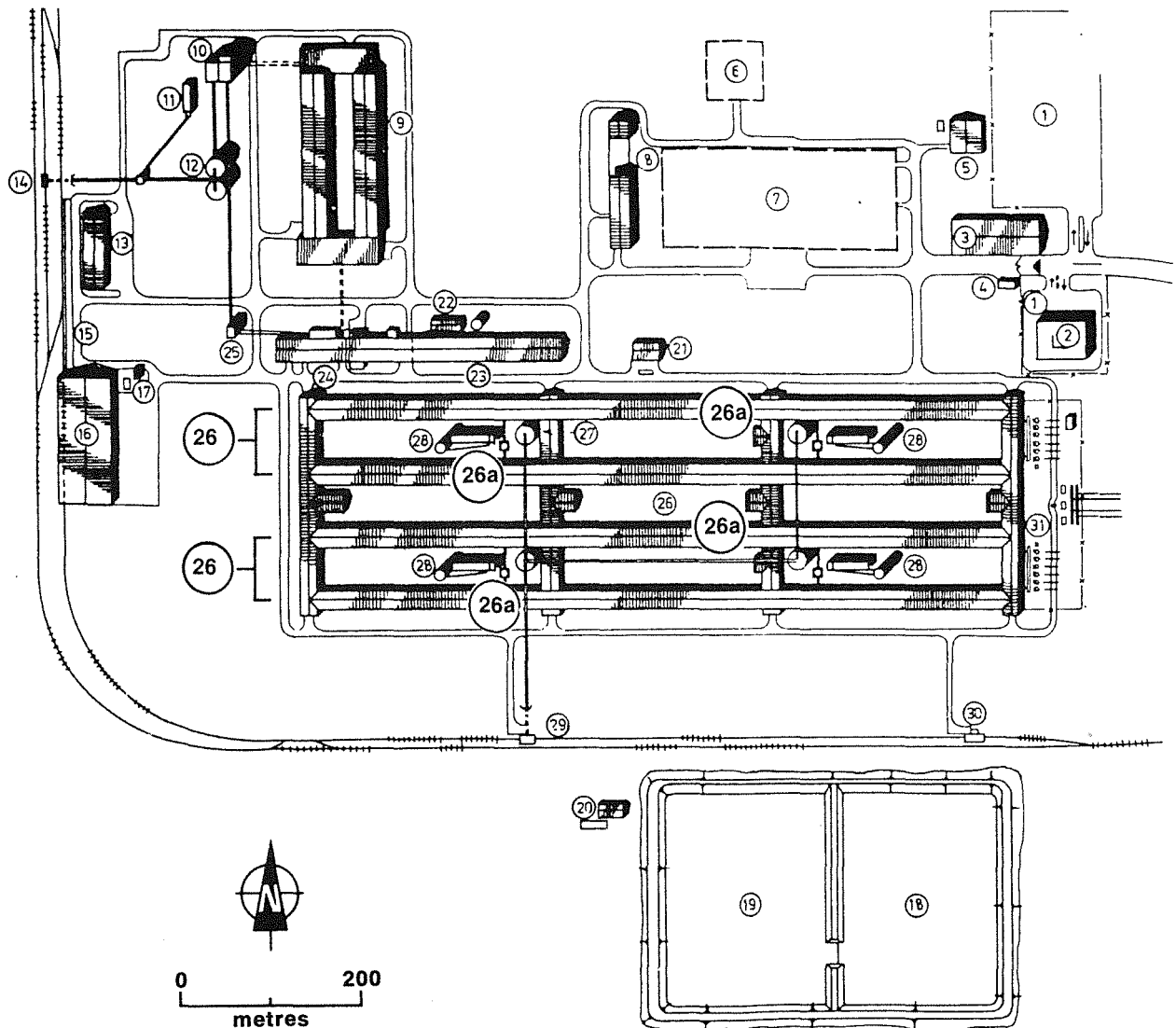
5.3.1 POTROOM EMISSIONS

Pot emissions consist of both gases and particulates. Gases consist mainly of oxides of carbon (CO and CO₂), hydrogen fluoride (HF) and sulphur dioxide (SO₂). Sulphur dioxide is generated by the oxidation of sulphur (approximately 3%) in the anode. Generation of total fluorides (32.0 kg Ft/tAl) is directly and linearly related to the chemical composition of the electrolyte or bath (i.e. the molten cryolite and aluminium fluoride used to dissolve the aluminium oxide).

The pots are hooded to allow capture of a high percentage of the primary emissions which are then treated in the dry scrubber. The ERMP states that this pot hooding efficiency would be 97.5%.

Secondary emissions are those that escape collection by the hoods in the pot rooms and escape via the potroom roof vents. Pot hoods operate under negative pressure so that under normal circumstances air emissions cannot escape. However abnormal short-term metallurgical conditions can cause excess fluoride emissions and hence generate additional secondary emissions from individual pots. Major factors are fluctuations in electrical load, bath ratio*, bath temperature, and anode effects*. Tapping of metal from the pot, anode replacement, sample

procurement, and periodic inspections necessitate removal of some of the pot hoods. It is mostly during these periods, and particularly during the replacement of anodes that the loss of secondary emissions from the pot to the building roof vents would occur. The ERMP states that 80% of the total fluorides emitted from the plant would be emitted as secondary emissions via the roof monitors* (Helleman, p. 4-7).



Key

- | | |
|--------------------------------------|------------------------------------|
| 1. Parking | 17. Cooling tower |
| 2. Administration building | 18. Settling pond |
| 3. Personnel building | 19. Evaporation pond |
| 4. Emergency vehicles | 20. Sewage treatment plant |
| 5. Laboratory environmental services | 21. Operations building |
| 6. Water treatment plant | 22. Compressor building |
| 7. Workshops and warehouses | 23. Anode storage |
| 8. Pot relining building | 24. Rodding room |
| 9. Baking furnace building | 25. Secondary butt crusher |
| 10. Green carbon building | 26. Potlines |
| 11. Pitch storage | 26a. Potrooms |
| 12. Coke storage | 27. Alumina silos |
| 13. Bagged goods | 28. Fume control |
| 14. Coke and pitch unloading | 29. Alumina unloading |
| 15. Railroad unloading dock | 30. Track scale |
| 16. Metal service building | 31. Switch gear and rectifier yard |

Source: ERMP

Figure 14 — General Arrangement of Smelter.

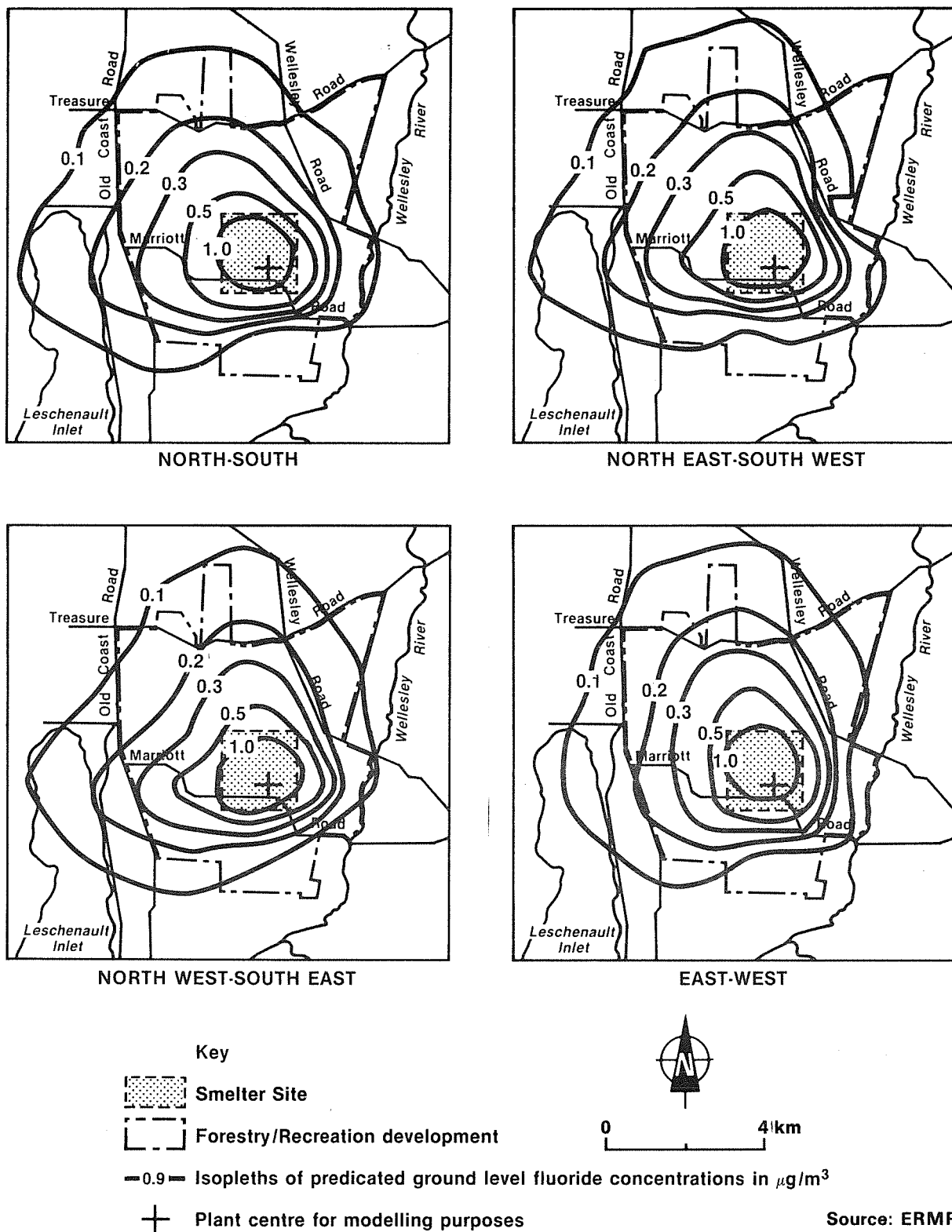


Figure 15 — Influence of Smelter Orientation on Dispersion Characteristics.

5.3.2 PRIMARY SCRUBBER EMISSIONS

The primary emissions emitted by the smelting pots and collected by the hoods would be treated by a dry alumina scrubbing process. Gaseous fluorides would be chemically absorbed onto alumina and then collected with particulate fluorides by the four scrubbers. The scrubbed emissions would then be discharged into the atmosphere, via four stacks and the fluoride enriched alumina would be recycled back to the smelting pots.

Table 4 Long-term Average Airborne Waste Production, Equipment collection efficiencies and Airborne Emissions for the Smelter (excluding scrubbers). Emissions expressed as kilogram per tonne of aluminium produced (kg/tAl).

Source	Constituent	Waste Products (kg/tAl)	Collection Efficiency (%)	Secondary Airborne Emissions (kg/tAl)
Potroom	Gaseous Fluoride	16	97.5 (hoods)	0.4
	Particulate Fluoride	16	97.5 (hoods)	0.4
	Sulphur Dioxide	24	97.5 (hoods)	0.6
Anode Bake Furnace	Gaseous Fluoride	0.25	100	0
	Particulate Fluoride	0	100	0
	Sulphur Dioxide	0.8	100	0
	Carbon Particulates	1.2	100	0
	Tar Vapour	0.6	100	0

Source : ERMP

Table 5 Long-Term Average Collection Efficiencies and Airborne Emissions of the Smelter Scrubbers (expressed as kilogram per tonne of aluminium produced (kg/tAl)).

Source	Constituent	Waste Input to the scrubber (kg/tAl)	Collection Efficiency of the scrubber (%)	Airborne Emissions through the stacks (kg/tAl)
Potroom Scrubbers	Gaseous Fluoride	15.6	99.5	0.08
	Particulate Fluoride	15.6	99.5	0.08
	Sulphur Dioxide	23.4	0	23.4
Anode Bake Furnace Scrubber	Gaseous Fluoride	0.25	90	0.03
	Sulphur Dioxide	0.8	0	0.8
	Carbon Particulates	1.2	99	0.01
	Tar Vapour	0.6	90	0.06

Source : ERMP

5.3.3 ANODE BAKING FURNACE EMISSIONS

Flue gases from the anode baking furnace would consist primarily of natural gas combustion products. Pitch fumes* driven from the green anodes* during baking would also be present, including some sulphur dioxide. Small amounts of fluoride from the recycled anode butts will also be evolved in the baking process.

A dry alumina scrubber, similar to that proposed for pot fume scrubbing, but having a fluoride air collection efficiency of 90% (rather than 99.5% for the potroom scrubber for the potlines) would capture the fluoride and pitch emissions.

5.4 LIQUID WASTES

The proposed plant would produce quantities of process wastewater. However, the ERMP does not mention in detail what quantity or quality of wastewater would be produced or how the wastewater would be treated or managed. Information provided in the ERMP is shown in Table 6.

Liquid waste disposal is discussed in Section 7.2.3 of this Assessment Report.

Table 6 Liquid Wastes

Nature	Quantity	Description
Runoff (average year)	250 ML	pH — 7 Fluoride — 10 mg/L max
Domestic	35 ML	High in suspended solids and biochemical oxygen demand
Process cooling water	N/A	N/A

N/A — Not Available

Source : ERMP

5.5 SOLID WASTES

The ERMP states that the cathodes would require replacement after about 3-5 years. From about 1992, between 6550 tonnes and 9650 tonnes per year of used (spent) cathode material and 6210 tonnes of refractory* lining and other wastes would be generated and would need to be disposed of annually. (Table 7)

Solid waste disposal is discussed in Section 7.2.4.

5.6 NOISE

Most of the noise generated by the smelter would be in the low frequency range. The ERMP states that noise would be controlled through in-house management (Helleman, p. 6-11). The predicted extent of the noise level contours, as presented in the ERMP, is shown in Figure 16.

Other noise would result from material and personnel movements (e.g. increase in traffic) and from the smelter's intercom system.

5.7 THE WORKFORCE

5.7.1 CONSTRUCTION

According to the ERMP and the Social Needs Study (Dames and Moore, 1985b), an average of 800 persons would be employed on-site over a three-year period. This number could peak at 2200 for a short period of time (Dames and Moore, 1985b). The ERMP assumes that an existing pool of local labour could be supplemented by workers commuting on a weekly basis from Perth, living during the week in construction camp(s) located within the Kemerton area or in private accommodation in the local area.

5.7.2 OPERATIONAL

Eight hundred permanent jobs are expected to be generated by the smelter.

The smelter would operate on a continuous shiftwork basis. Consequently, employee traffic would be generated on neighbouring roads three times per day during shift change periods.

5.8 SMELTER CONSTRUCTION, INTERRUPTION, DECOMMISSIONING AND REHABILITATION

The ERMP proposes that the smelter would be constructed over approximately a three-year span, starting sometime in mid-1985.

The ERMP states that in the event of interruption the smelter would be placed on a care and maintenance basis to facilitate a recommencement of operations.

There are no firm plans presented in the ERMP for decommissioning of the smelter or the rehabilitation of the smelter site at the end of its useful life.

Table 7 Solid Wastes

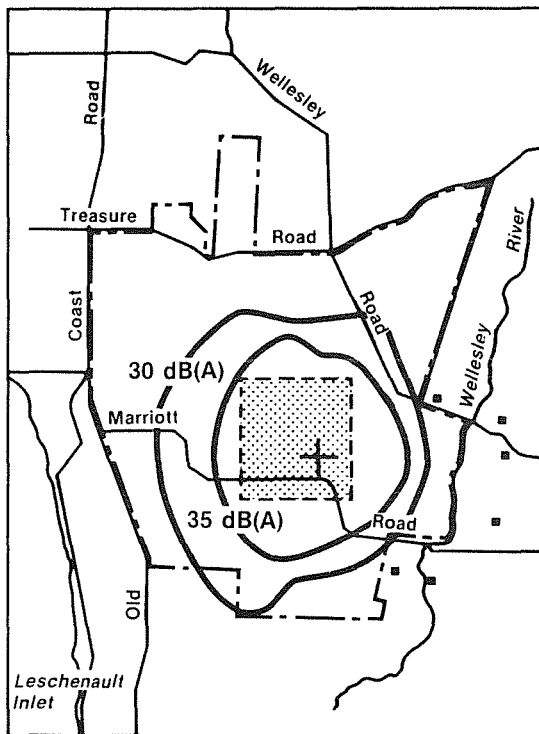
SOURCE	TYPE	DESCRIPTION	QUANTITY (TONNES /YEAR)	DISPOSAL METHOD
1. De-lining shop	Spent cathodes	Mixed size fraction various solid components	6550(1)-9650	N/A (long term)
2. Cast house dross reclamation	Dross reclamation residue	Fine product 8-10% aluminium	150	N/A
3. Electrode paste plant	Carbon material floor sweepings	Carbon contaminated with foreign materials	440	N/A
4. Rodding shop	Bath material floor sweepings	Bath material which cannot be recycled because of contamination	200	Joint disposal
5. Rodding shop	Shot blaster refuse	Bath and shot and carbon and iron mixture	250	Method not finalised
6. Potline	Bath and carbon dust	Solidified bath contaminated with carbon fines and pieces	400	N/A
7. Plant sweepings	Spilled contaminated material	Mixture of coke, bath, carbon and other material	800	N/A
8. Potline services	Ladles	Refractory material	70	N/A
9. Electrode bake oven	Refractory lining	Refractory brick(2) non-contaminated	2400	Municipal landfill
10. Electrode bake oven	Bag filter dust	Fine coke dust	1000	Yet to be determined
11. Cast house furnace refractories	Refractory lining	Refractory brick non-contaminated(2)	80	Municipal landfill
12. Rodding shop	Ladles and cast iron furnace	Refractory brick non-contaminated(2)	70	Municipal landfill
13. Potline	Ladle skimming	Aluminium	1400	Sold for aluminium recovery
14. Plant wide	Packaging and domestic waste	Packaging, paper putrescible waste, etc.	350	Municipal landfill
Total			12760-15860	

Source : ERMP

(1) During long-term normal operation. Peak production rate estimated at 9650 tpy.

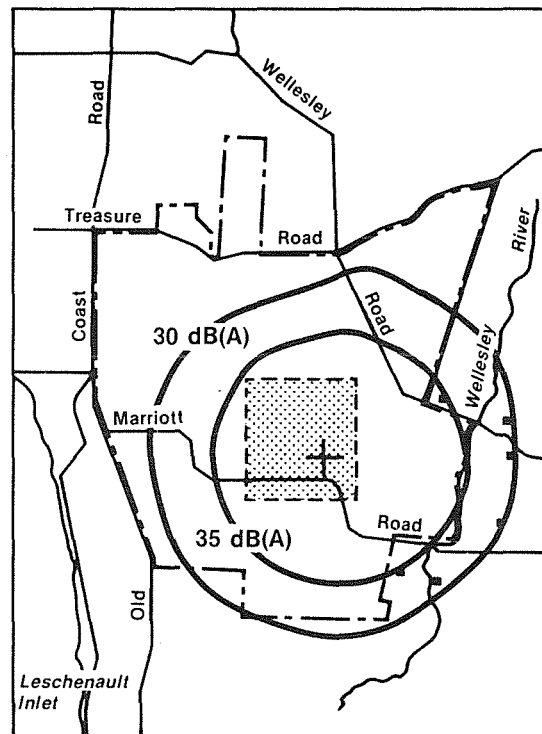
(2) Fluoride contained within the brick (less than 1.0%) is in a non-leachable, highly insoluble form.

N/A — Not Available



SUMMER

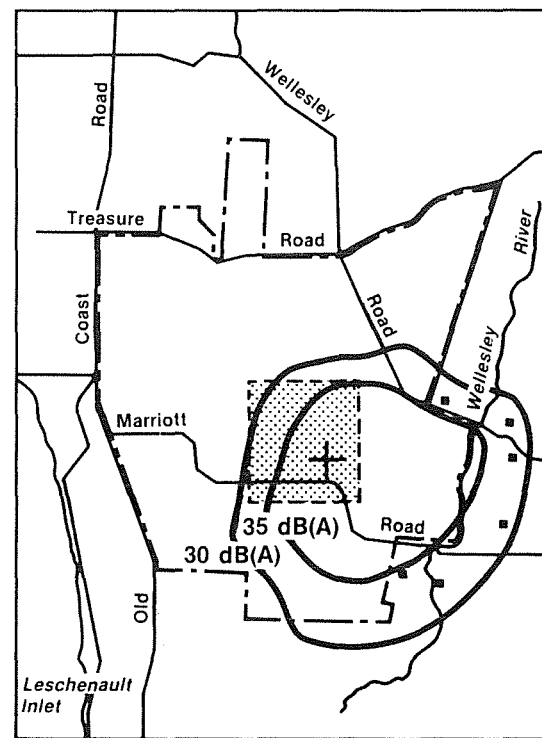
- Prevailing wind from ENE + E + ESE
- Wind speed 3-7m/sec
- Air humidity 58%
- Air temperature 28°C



SUMMER "INVERSION"

- No prevailing wind
- Wind speed less than 0.5m/sec
- Air humidity 58%
- Air temperature 28°C

- Key
- Smelter Site
 - Forestry/Recreation development
 - Closest residences
- Source: ERMP



WINTER

- Prevailing wind from WNW + NW + NNW
- Wind speed 4-8m/sec
- Air humidity 70%
- Air temperature 10°C

Figure 16 — Predicted Noise Levels.

6. REVIEW OF SUBMISSIONS

The ERMP was released for an eight-week review period which ended on 1 May 1985.

During this time, thirty-four public and twenty government submissions were received. All public submissions were acknowledged, and the Authority wishes to record here its appreciation of all persons and organisations who made submissions.

The submissions have been analysed in the following manner:

- submissions from public and community organisations have been analysed to extract the issues raised. These issues are summarised in Section 6.1, and a list of people and organisations making submissions is given in Appendix G;
- the submission from the Harvey Shire has been summarised, with their permission, and is presented in Section 6.2; and
- comment on the ERMP was received from a number of government agencies. These were circulated to the Commonwealth Department of Arts, Heritage and Environment, and to the proponent for their information and consideration. The proponent has responded to these in a separate submission to the Authority. The information contained in the original comments, and the proponent's responses thereto, have been considered by the Authority in the preparation of this Assessment Report.

6.1 ISSUES RAISED IN SUBMISSIONS FROM THE PUBLIC AND COMMUNITY ORGANISATIONS

The issues raised in this group of submissions have been grouped, and are summarised under the headings below and in Table 8.

The order of submissions listed in Table 8 bears no relation to the order of the list of people and organisations making submissions in Appendix G.

The submissions received varied in the complexity and breadth of issues raised, ranging from one to seventeen issues per submission.

Many submissions raised various points on a single topic; this is not reflected in Table 8, where only the broader topic itself is scored, but the detailed points raised are summarised in the following text.

6.1.1 ECONOMIC AND SOCIAL ISSUES

6.1.1.1 Need for the Proposal, Economic Viability and Benefits to Community

- doubts on the economic viability or advantages of the smelter to the community; reasons unconvincing;
- State Government should not subsidise smelter, misuse of public funds, that the proposed development should be viable in its own right or not pursued, should not be at cost of environment;
- objection to promotion of project by State Government departments;
- completion of the approvals process in time for the Commonwealth Investment Allowance (by 30 June 1985) is a social and economic cost to the community;
- alternative industries (e.g. rural, tourism) more worthy than smelter of public funding;
- poor (or no) cost-benefit analysis of the use of fossil fuel by smelter, and costs of provision of infrastructure and energy, fear that economic benefits will not be sustainable, particularly after plant closure;
- concern that the major proportion of smelter's profits will leave Australia;
- costs of environmental degradation are at least equal to the costs of mitigation;
- concern that corporate (proponent) tax evasion is likely;
- concern that smelter will have negative economic effects on other sectors of the economy, particularly industry (the Gregory effect);
- concern that values of direct and indirect subsidies to proponent will be underestimated;
- concern that the smelter is an inappropriate use of valuable resources, particularly water, gas, coal, bauxite and renewable native forests;
- concern that benefits are primarily restricted to increased employment, smelter jobs will cost \$1 million each, number of new jobs over-estimated, few jobs for unskilled and unemployed;
- concern that smelter will make Bunbury less attractive as a tourist destination;
- proponent's claim that smelter will encourage downstream processing of aluminium is disputed.

Table 8 Summary of Issues Raised in Submissions from the Public or from Community Organisations.

ISSUES RAISED IN PUBLIC SUBMISSIONS	SUBMISSION NUMBER																																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	TOTAL	
Need for proposal/economic viability/ benefits to community		*				*						*						*		*		*				*	*					*				9
Site selection/land use/planning/ amenity	*	*		*		*	*	*	*			*	*		*	*	*	*	*	*		*		*			*		*		*	*	*			22
Compensation/penalties	*	*	*	*			*	*				*	*	*	*	*		*	*				*		*		*					*	*			16
Human health/occupational hygiene			*				*									*		*	*				*			*	*	*					*		7	
Road and rail traffic					*			*								*										*	*		*						5	
Plant design/atmospheric emission controls/standards						*							*				*	*			*		*		*			*					*		8	
Management of solid waste						*		*				*					*	*		*	*	*	*			*	*			*		*			12	
Water demand/liquid waste disposal/ groundwater						*	*									*		*		*	*	*				*	*	*		*			*		10	
Buffer zone/management of zone						*										*		*		*	*	*			*	*	*		*		*		*		7	
ERMP — adequacy						*		*		*		*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	14	
Atmospheric dispersion modelling						*		*								*		*			*	*	*	*		*	*	*					*		9	
Ecosystem processes		*									*	*					*	*							*	*	*		*	*		*	*		8	
Agriculture							*	*					*		*											*	*	*							5	
Soils/groundwater							*				*					*																	*	*	3	
Wetlands		*													*						*				*	*				*	*				7	
Leschenault Inlet		*													*											*	*								3	
Native plants/plant communities	*						*			*																*	*			*					5	
Baseline studies/environmental management/monitoring									*		*					*					*					*	*					*			7	

6.1.1.2 Site Selection, Land Use, Planning, Residential and Rural Amenity of the Area

- disagree that the proposed smelter site is of “low economic value”, object to Kemerton site;
- object to re-zoning of site from rural to industrial, smelter should be placed elsewhere in an area of low value; a serious planning error is being made;
- fewer people would be affected at Worsley Siding site;
- extent of heavy minerals deposit near Treasure Road underestimated, concern about possible alienation of scarce resource, should plan for further mining;
- the rural nature of area will be spoilt, residential and rural amenity will decline, Labor Party is reducing local quality of life;
- coastal strip will be alienated from the people of the expanding Bunbury region, major impacts on Myalup and Binningup;
- uncertainty on the routing of the infrastructure corridor, interference with rural activities;
- construction and operation of smelter will cause an unacceptable increase in ambient noise levels;
- smelter stacks will intrude on an expensive view;
- preferred rail spur route is along Cactus Drain easement;
- loss of Dardanup loam soils should be avoided;
- rail over road option should not be implemented;
- object to a possible eastern rail loop;
- central road realignment option should be pursued;
- smelter site alienates land for possible future northward expansion of greater Bunbury;
- smelter site was chosen before proponent’s preparation and Authority approval of ERMP, no consultation with local community, alternative sites not properly considered;
- the high rainfall (South West) area should be reserved for tourism, agricultural and residential purposes;
- impacts of project on local population under-estimated, particularly the impact of numbers (unspecified) of relocated public servants, inadequate health and child care facilities, a sexual assault referral centre, and women’s refuge requires a comprehensive social needs study;
- project will cause a rise in house prices, shortage of accommodation, displacement of low income earners from rented premises;
- dispute route of proposed Controlled Access Highway;
- concern that presence of smelter and infrastructure corridor will encourage the establishment of other heavy or ancillary industry in area, with greater cumulative impacts;
- Kemerton site will result in greater loss of forest because of the need for long power transmission lines;
- proximity of construction camp will reduce local amenity (and safety).

6.1.1.3 Compensation for Disturbance, Loss or for Forced Relocation, Penalties for Violation

- fluoride pollution of rainwater a concern, cannot afford an alternative water source, compensation is necessary;
- dairying property will become worthless, fluoride emissions will reduce profitability; pastures will be damaged, health of cattle and horses will be damaged;
- (general) decline in property values to the point of unsaleability, smelter will harm agriculture;
- agricultural or veterinary advice to landowners is a form of duress, should not be required if the ERMP is correct;
- replacement of fluoride-sensitive plants (or animals) with tolerant types unacceptable;
- project should only proceed if proponent accepts full liability for damage compensation, fears that proponent will avoid liability;
- adequate compensation required for loss of land because of road or rail realignments;
- who pays for the costs of modified management practices forced by existence of smelter;
- objection to government (public) resumption of land, all land within 0.1 microgram gaseous fluoride per cubic metre isopleth should be owned by proponent;
- amounts offered for resumed land inadequate and do not account for costs of forced relocation;
- penalties should be specified and enforced if the smelter exceeds fluoride emission limits;
- concern that SCM titanium plant has never been prosecuted for spillages, and that smelter will be no different;

- State Agreement Act not finalised, therefore it is impossible to tell whether environmental and health safeguards are adequate;
- damaging effects of fluoride are difficult to separate from those of other factors, therefore determination of claims for restitution will be difficult;
- specific concerns of damage to cattle, horses, grapevines, stone fruit, market gardens and cash crops, marron farming, subterranean clovers.

6.1.1.4 Human Health and Occupational Hygiene

- fluoride pollution of rainwater a concern, possibility of human fluorosis from drinking polluted rainwater;
- general concern on the effects of fluoride emissions on human health;
- concern about the occupational health of smelter workforce from hydrogen fluoride, coal tar pitch volatiles, dust, asbestos, electromagnetic radiation, alumina, aluminium and coke dust;
- concern about duration and frequency of exposure of workers to various industrial pollutants and/or hazardous emissions, and relationship of likely exposure regimes to Australian or other standards;
- insufficient statement (by proponent) of likely airborne fluoride concentrations at various stages of pot operations;
- concern about synergistic effects of smoking on smelter workers' health;
- concern about transportation and handling risks of aluminium chloride, cryolite and tar pitch;
- demand for monitoring of (local) human health, rainwater used for drinking and anxiety levels;
- concern at likelihood of increased noise, mostly from the point of view of amenity loss;
- concern that smelter will produce odours;
- concern that Australind will be polluted.

6.1.1.5 Road and Rail Traffic

- increased danger from major increase in daily truck traffic;
- want a bypass road constructed around Australind prior to construction of the smelter;
- increased truck traffic will diminish quality of lifestyle and increase damage to local roads;
- concern about increase of noise from smelter-related traffic;
- concern at inconvenience caused by proposed closure of Partridge Road for reconstruction and upgrading;
- nearby railway will destroy rural tranquility during both construction and operation;
- use of rail preferred for transportation over road, rail spur should be operational before construction of smelter begins.

6.1.2 DESIGN, CONSTRUCTION AND OPERATION OF THE SMELTER AND BUFFER ZONE

6.1.2.1 Plant Design, Atmospheric Emission Controls — Standards, Technology

- government should reserve the right to impose stricter emission controls;
- stricter emission standards are required elsewhere, 1 kilogram fluoride per tonne aluminium is too high, suggestions ranged between 0.14-0.76kg F/tAl, doubts that proponent is proposing "most efficient and proven technology";
- importance of short-term variations in atmospheric fluoride emissions are discounted by proponent, other countries use shorter averaging periods (30 minutes to 24 hours), shorter term emission standards are necessary;
- proponent's objection to installation of wet scrubbers for fluoride and sulphur dioxide because of cost is not acceptable, smelter should at least have the design capability to be retrofitted with wet scrubbers;
- proponent should be required to install booster extractors and stainless steel hoods on pots;
- proponent did not discuss the alternative chloride process (or other processes) for smelting aluminium, which is stated to permit more flexible operation, lower energy consumption and less pollution;
- all wastes should be internalised and neutralised and/or recycled;
- failing the above point, the Authority should insist on tighter emission standards, independent monitoring and full accountability by the proponent;
- human failure is the main cause of the breakdown of pollution control equipment;
- concern that smelter site chosen has insufficient clearance above water table, 1-2 metres is available, but 5-8 metres is needed;

- statements of projected smelter energy use (deceptively) understated;
- proponent has not specified contingency plans for total power failure, physical damage to pots, failure of a dry scrubber unit, leakage from liquid or solid waste storage;
- why not use titanium diboride cathodes, which are stated to be 20 percent more energy efficient;
- proponent has given no consideration to the utilisation of waste heat by the smelter;
- concern over possible use of asbestos in plant, suggestion that other materials be used instead.

6.1.2.2 Management of Solid Wastes

- lack of resolution of method(s) for disposal of solid (cathode) waste is unacceptable, cathode waste disposal should be the subject of its own ERMP, which would include evaluation of alternative methods;
- concern over capacity of local tip to accommodate non-hazardous municipal waste from smelter, proponent should bear costs of municipal waste disposal;
- concern at lack of control of waste disposal, lack of nomination of responsible authority;
- total objection to burial or open pit disposal of solid (cathode) waste on site, as it will cause groundwater pollution;
- lack of consideration of the quantities of hazardous wastes to be disposed of during plant decommissioning;
- sites should be proposed for the disposal of solid wastes and/or dispose of solid wastes in desert;
- concern that interim handling of hazardous wastes has not been addressed, lack of consideration of possible methods (e.g. clay-lined pits), and the hazards associated with their use;
- concern that contract processing of waste bath material may not be sufficiently controlled, and that inadequate disposal of contractor's wastes may occur;
- concern about methods for disposal of cyanide waste, possibility that it will pollute groundwater;
- proponent should be required to establish a trust fund for solid waste management, question as to proper form of administration for the fund;
- bag filter dust should be recycled to the electrode (anode) bake;
- solid wastes should be stored in a covered building with a concrete floor.

6.1.2.3 Water Demand, Disposal of Liquid Wastes, Effects on Groundwater

- deep well injection or marine disposal of liquid waste "nebulous" and/or unacceptable;
- disposal of liquid wastes to "surrounding watercourses" or by "site irrigation" completely unacceptable, and/or unacceptable in the absence of supporting technical information;
- lack of information on leaching (or fluoride-fixing) characteristics of soils unacceptable as leaching characteristics will determine the suitability of soils for liquid waste disposal, concerns about groundwater pollution;
- conflict of proposed groundwater use by smelter with the needs of irrigated agriculture or other users (e.g. Bunbury), groundwater should not be allocated to smelter;
- concern that (fluoride) polluted groundwater will affect Kemerton wetlands and/or Leschenault Inlet, modelling of fluoride transport characteristics in groundwater not done;
- concern that exploitation of groundwater will lead to widespread drawdown of the water table, and drying out of wetlands;
- concern at possibility of saline water intrusion into aquifers from overpumping, water yields unknown, overpumping may prevent recharge of aquifers;
- much more research on all aspects of groundwater management and behaviour is needed;
- concern that effluent storage ponds will leak (and pollute groundwater), type of lining of effluent ponds not specified;
- no commitment from proponent to manage surface drainage of the site;
- no statement (in ERMP) of the likely frequency of overtopping of effluent ponds and diversion of effluent to natural watercourses;
- liquid wastes should be retained on site, water recycling should be investigated.

6.1.2.4 Shelter Belt (Buffer Zone) and its Management

- objection(s) to the clearing of woodland to establish pines, woodland is a regionally important resource;

- *Pinus* species are sensitive to fluoride in the 0.25-1.0 microgram gaseous fluoride per cubic metre range, concern at possible loss of trees, and the expense and wastage involved;
- effects of air pollution in a Mediterranean climate not known;
- *Pinus radiata* is susceptible to *Phytophthora* therefore it is not advisable to use it;
- growth rates of trees may not be sufficient to adequately absorb fluoride, no estimates of likely efficiency of fluoride removal by trees;
- no information given on the proposed layout of trees, their density etc. that is spacing criteria to maximise fluoride removal from air;
- no evaluation of the effects of, or contingency planning for the loss of buffer zone trees from pollution, fire, insect attack, pathogens;
- object to loss of (marri) trees by clearing for pine plantations and/or air pollution.

6.1.3 ADEQUACY OF THE ERMP ITSELF AND OF THE ERMP PROCESS

6.1.3.1 The ERMP

- ERMP is inadequate, e.g. "hypothetical to the point of fraud", "misleading", "shoddy", "vague", "poor quality", "poor standard", "biased";
- botanical survey and information in ERMP are inadequate, geographical coverage incomplete, only two of several plant communities are described, no reference to Blackwell and Cala (1982) study, failure to mention four species of rare plants known to occur on the site;
- no assessment of risks of air and water pollution to Leschenault Inlet;
- lack of time for adequate public review of ERMP, particularly as there were six related documents available for public review concurrently, these documents were released late;
- statements of environmental impact in the ERMP are "too qualified", and should be "tightened up" before plant proceeds;
- cumulative environmental effects of smelter with those of other existing or proposed industries in the area are not considered, e.g. with those of the Australind SCM titanium plant and the proposed chlor-alkali plant;
- "death of marri" misleadingly described as a "decline in numbers", effects of smelter emissions on eucalypts and ecosystems understated, loss of plant species other than marri ignored;
- objection to lack of a survey for Aboriginal sites, smelter may cause loss of Aboriginal heritage;
- impacts of additional (smelter-related) bauxite mining on jarrah forest not addressed;
- statements on the distribution of Bassendean Sands compared with other soil types are misleading;
- the effects of sulphur dioxide emissions from the smelter are not addressed in the ERMP, neither are the damaging synergistic effects of sulphur dioxide and fluoride on plants;
- complaints of the superficiality of fauna and flora surveys, statements in the ERMP that there are no rare or endangered species on the site are not supportable.

6.1.3.2 Atmospheric Dispersion Modelling

- only one year of meteorological data from Glen Iris site is inadequate for impact prediction, why were the local Kemerton data not used, or not compared with the Bunbury data?
- modelling does not adequately reflect the degree of south-westerly wind influence, therefore meteorological data are inadequate; concern that the modelling does not adequately reflect the "sea breeze effect";
- modelling is "not convincing", isopleths are "too localised";
- incorrect model parameter values, for example for fluoride decay and surface roughness have been used, and this will result in impacts being underestimated;
- the BLP model does not accurately represent atypical conditions, for example atmospheric inversions;
- the sensitivity of the BLP model to different values for surface roughness, averaging period and fluoride decay factor has not been shown;
- important short-term pollution episodes have not been modelled, for example intense, short-term fumigations lasting for 12 or 24 hours;
- the effects of rainfall on the smelter's plume of atmospheric emissions have not been modelled;
- calculations of atmospheric fluoride loadings to surrounding land and waterbodies needed;
- a specific airshed study of the site is required;
- no modelling has been done of atmospheric fluoride dispersion without pines surrounding the site, this would result in far more severe and widespread fluoride toxicity and other effects.

6.1.4 OTHER SPECIFIC ENVIRONMENTAL ISSUES

This section addresses specific environmental issues which may have been alluded to elsewhere.

6.1.4.1 Ecosystem Processes

- concern that acid rain (from sulphur dioxide emissions) will damage agriculture, woodlands and wetlands by lowering pH of soils and water, (releasing methyl mercury and polluting fish);
- concern that smelter emissions and construction will cause a “loss of ecology”, be an “environmental disaster”;
- environmental costs of the Kemerton site have been underestimated;
- there is insufficient knowledge of the ways in which fluoride will affect ecosystems, particularly critical processes such as nutrient recycling, decomposition and mycorrhizal fungi, chronic effects of fluoride on plants poorly known;
- there has been an underestimation of the level of environmental exposure to fluoride, that the importance of the effects of fluoride have been played down, that there will be biomagnification (or concentration) of fluoride through food chains with unknown effects;
- fluoride will cause destabilisation of insect populations, and damage to populations of pollinators;
- synergistic (combined) effects of fluoride and sulphur dioxide on plants via dilation of stomata unknown;
- the smelter will contribute to global pollution via the “greenhouse effect”;
- concern that the loss of fluoride-sensitive species from local habitats will cause instability of ecosystem;
- concern that certain native plant species will accumulate toxic fluoro-acetate, which is toxic to both humans and animals.

6.1.4.2 Agriculture

- concern that chronic or short-term fluoride emissions will damage pastures, affect cattle and horses, cause reductions in milk yield, damage sensitive plants (e.g. grapevines and stone fruit), affect market gardening, cash crops and marron farming;
- fluoride isopleths in ERMP do not demonstrate the possibility of damage to agriculture due to short-term, high concentrations of fluorides.

6.1.4.3 Soils and Groundwater

- concern that fluoride emissions will pollute groundwater;
- concern that groundwater will be contaminated by liquid waste from the smelter;
- concern that the Bassendean Sands will not fix fluoride, and that much fluoride will leach to the groundwater flow, for these soils more investigation is needed of the time and manner of fluoride absorption and the characteristics of surface and groundwater flow, concern at possible changes to the groundwater table, and possible changes to soil pH;
- concern that SO₂ emissions may decrease pH of soils, groundwater and surface waters.

6.1.4.4 Wetlands

- concern that smelter will affect waterways, wetlands should be protected from the effects of the smelter, insufficient research on fluoride effects on aquatic biota, that smelter will result in destruction of the few remaining wetlands;
- the south-eastern wetlands is important, concern at possibility of further loss of a scarce resource, that is vegetation is still intact and might be lost or degraded, retention is a priority;
- concern that smelter employees will damage wetlands, particularly during the smelter construction phase;
- concern that fluoride-polluted groundwater will damage wetlands and their biota (by acute or chronic fluoride toxicity, food-chain enrichment, sediment accumulation of fluoride);
- concern that wetlands will be lost as a (local) recreational resource;
- statement that the Authority (Environmental Protection Authority, 1983) highlighted the importance of the Kemerton wetlands, and that Australia has a legal obligation to protect them under the Ramsar Convention;
- statement that some of the wetlands are degraded, but that they could be improved with management.

6.1.4.5 Leschenault Inlet

- smelter will affect Leschenault Inlet, directly via air pollution, and via water pollution carried by the Wellesley and Brunswick Rivers;

- there is insufficient research on the effects of fluoride on the Inlet's biota;
- concern that spillages of aluminium fluoride or cryolite in the Port of Bunbury will pollute Leschenault Inlet;
- concern that Leschenault Inlet is already under stress, is an important waterbird habitat and fish nursery, has valuable fringing vegetation, and is the subject of an Authority System 6 recommendation for a regional park.

6.1.4.6 Native Terrestrial Plants and Plant Communities

- concern at "loss of forest" or other native vegetation, that smelter will cause a "loss of bush";
- loss of 1000 hectares of native vegetation is undesirable;
- concern that *Pultenaea skinneri*, a gazetted rare pea species, occurs in the best population known for WA near the south-eastern wetland;
- concern at the lack of comprehensive fluoride fumigation trials on native plant species, fumigation tests not done with unstressed plants;
- concern that extreme short-term fluoride emissions will damage or kill native vegetation;
- concern that the existence of the smelter will lead to a greater level of bauxite mining, and a greater loss of the jarrah forest resource;
- concern that *Melaleuca* trees will be lost from swamps;
- statements that the remaining areas of woodland are of significant regional conservation value.

6.1.4.7 Baseline Studies, Environmental Management and Monitoring

- the botanical survey and information reported in the ERMP is an inadequate basis for a baseline study;
- concern at lack of baseline studies for the kemerton site (or for the greater area), flora and fauna studies are inadequate, at least one year of baseline studies are required, and that claims (in the ERMP) of no rare or endangered species are not supportable;
- monitoring of the smelter operation, the buffer zone and surrounding lands should be carried out by an independent body (the Government), at the proponent's expense, and the results should be publicly available (in both raw and processed form), the public should have access to the development of the monitoring programme;
- atmospheric monitoring should begin immediately at five sites, before smelter is operational;
- the flora should be monitored in a statistically valid way;
- environmental education programmes should be provided for **all** workers at smelter site;
- baseline studies are required for woodland and wetland ecosystems, including Leschenault Inlet, monitoring will be of little value unless this is done;
- the proponent should publish a commitment to monitor dry scrubber units, and define sampling techniques for dangerous hydrocarbons in the workplace;
- baseline studies of insect (invertebrate) populations are required (as they are sensitive indicators of environmental change), the lack of invertebrate species inventories from woodlands and wetlands would make monitoring difficult;
- there is a need to monitor background fluoride levels in sediments and biota of wetlands;
- a monitoring programme will need:
 - knowledge of pollutant pathways through ecosystems;
 - identification of key species, and knowledge of tolerances of those species to individual pollutants, and to mixtures of pollutants;
 - comprehensive species inventories;
 - the setting of maximum allowable pollutant levels for each ecosystem, key species, groundwater and air;
- if the proponent is genuinely concerned about the environment then they will set up the above programme prior to commissioning the smelter.

6.2 ISSUES RAISED IN TWO SUBMISSIONS FROM THE SHIRE OF HARVEY

The Shire of Harvey made two submissions to the Authority, one on the Aluminium Smelter Services Corridor Study (Dames and Moore, 1985a), and the other on the ERMP. These are summarised below.

Copies of both submissions are available from the Shire of Harvey Office, Uduc Road, Harvey, or from the Department of Conservation and Environment library, 1 Mount Street, Perth.

6.2.1 SUBMISSION ON THE ALUMINIUM SMELTER SERVICES CORRIDOR STUDY

The Shire has discussed various options for the routing of the smelter services corridors with affected landowners, and general acceptance of the following recommendations was obtained:

- railway access can be provided with the least disruption to the local community by selection of the Cactus Channel Option and by incorporating the Beaufort Drain Reserve within the 40 metre rail reservation;
- to ensure that an on-going conflict does not arise, it is recommended that the house located at the junction of Wellesley Road and Beaufort Drain be acquired by Westrail;
- a single spur railway should be provided from the South West Railway line to the Kemerton site and the South West Highway should be deviated to the central option. A level crossing should be provided on the Highway with appropriate safety mechanisms provided in accordance with the recommendation of the Railway Crossing Protection Committee;
- adequate road access to both the east and west of the Kemerton site, will be required prior to the smelter construction. It is suggested that the existing road system be upgraded to a satisfactory standard. It is acknowledged that this will be subject to further examination by the Consultants employed to prepare the Community Needs Study Report; and
- consideration should be given to the alignment of a services corridor west of the Kemerton area to allow for the construction of a pipeline to the Indian Ocean for the discharge of contaminated water in the event that on-site disposal methods cannot be resolved.

6.2.2 SUBMISSION ON THE ERMP/DRAFT EIS

The submission by the Shire of Harvey on the ERMP raised points on a variety of issues. These are summarised under their respective headings below.

6.2.2.1 Environmental Considerations

- investigations on the likely effects of fluoride emissions on irrigated pastures have not commenced and approaches by the Department of Agriculture for funds to commence those studies have proved unsuccessful. Baseline studies on the existing ground level concentrations of fluoride and the condition of local dairy herds have not been considered. A positive commitment should be given on when those studies will be commenced and details should be provided before the release of a final public document;
- the ERMP states that a long-term average rate of airborne fluoride emission shall not exceed 1 kg per tonne of metal produced. The appropriate legislation should be written to ensure that the plant is maintained in a condition that will ensure that the current and future airborne emissions meet that standard and that an appropriate penalty be devised, e.g. closure of the smelter, should the company fail to meet its obligations;
- the Final Environmental Impact Statement should address the problem of reducing the quantity of sulphur dioxide produced by the smelter and it should provide more comprehensive data on the total cumulative effect of the airborne emissions from industrial plants within the greater Bunbury region and, in particular, the possibility of "acid rain" being generated; the ERMP provides insufficient detail on the method of stormwater disposal and chemical composition of the purge water. The Final Environmental Impact Statement and the State Agreement Act should detail the final mode of water treatment;
- the disposal of liquid waste from the smelter should be addressed in a Public Environmental Report and a possible route for the ocean discharge pipe nominated if that option is adopted as the most acceptable option;
- soil from the Kemerton site should be analysed immediately to determine its fluoride fixing capacity. Resolution of the method of wastewater disposal through the Final Environmental Impact Statement and the State Agreement Act will deny the general public the ability to comment on an environmental matter of significant local importance;
- details should be provided on the effect the extraction of the required groundwater will have on the confined aquifers in the Kemerton area. A guarantee should be given that the agricultural and domestic consumers who currently have permits to extract water from the aquifer will not be adversely affected by the proposal;
- positive details should be provided in the Final Environmental Impact Statement on the possible effects of fluoride on the local estuarine system. In particular, the impact on the bottom sediments of the estuary, which provide the food chain necessary to support the breeding grounds which have developed at the northern end of the estuary, should be addressed;
- the Cathedral Avenue road reserve, which adjoins the Leschenault Inlet, has been listed by the National Trust as worthy of conservation. Cathedral Avenue is lined with paperbarks and the swamp lands between the road and the Leschenault Inlet form a natural breeding ground for local bird species. Positive detail should be provided in the Final Environmental Impact Statement on the effects the smelter will have on this natural resource;

- the final management plan for the Kemerton area should indicate a positive softwood planting programme for the Kemerton site and clearly define those areas which will be used for agro-forestry purposes in the short and long term;
- the planting of softwood should be commenced in the winter of 1985 and an annual programme implemented to re-vegetate all areas previously disturbed by farming practices. Areas which currently have natural stands of jarra and tuart woodland should not be logged until the long-term effects of fluoride on those woodlands have been determined;
- inference should not be made in the ERMP that downstream industries will be developed in close proximity to the smelter site;
- if the Kemerton wetlands are to be preserved for the future, the Government must be prepared to commit resources (in terms of manpower and finance), for the short and long-term management thereof. A similar commitment will be required on the inter-connecting wetlands located on private property;
- the creation of an important regional road through the southern extremity of the Kemerton area should be strongly opposed on environmental and aesthetic grounds; the results of the airshed modelling should be re-examined to ensure that the plant is located in the optimum position and the accuracy of the results should be checked by analysing what would have been the predicted ground level concentrations, and what levels are actually achieved, by using the model and available data from other smelters located in Australia;
- Council requires an assurance that the use of one year's meteorological data for modelling purposes is acceptable, particularly where major discrepancies have been found to exist between the Glen Iris and Kemerton meteorological stations;
- the monitoring programme outlined in the Environmental Management Report and ratified by the State Agreement Act should be carried out by an independent body, funded by the proponent, and its results should be made available to the Local Authority and the general public, particularly the results relating to domestic water supplies and ground level concentration of fluoride. The location of the monitoring stations should be determined in consultation with the Local Authority;
- a decision should be taken on the method of short and long-term disposal/storage of spent cathodes from the smelter and provision should be written into the State Agreement Act whereby the short-term option is to be implemented unless an environmentally sound long-term disposal option can be justified. The method of cathode disposal should be subject to constant review and Council wishes to record its opposition to the cathodes being disposed of within the district as municipal landfill;
- it must be acknowledged that while agricultural industry is declining as a major source of employment throughout the South West, it is still important to the economic wellbeing of the Shire of Harvey;
- the ducting adjacent to the pot hoods should be designed so that they can be easily modified at a future date if the appropriate technology becomes available to collect secondary emissions;
- the water levels in the Kemerton wetlands should not be raised if they will detrimentally affect the adjoining rural holdings, unless a long-term management plan has been resolved with the landowners concerned;
- a comprehensive monitoring programme should be commenced immediately to determine the condition of grazing stock and the pastures surrounding the Kemerton area;
- where the results of monitoring show that concentration of fluoride in domestic water supplies exceeds 1 part per million, the proponents should be required to drain and clean the storage facility and replenish the water from an unpolluted supply, or an alternate reticulated supply should be provided by the proponent;
- the native Christmas trees within the Kemerton area should be retained wherever possible;
- positive steps should be taken to ensure the declared plant *Pultenaea skinneri* is protected from adverse land use plans for the Kemerton area.

6.2.2.2 Social Implications

- concern was expressed that substantial infrastructure costs which will have to be met by the State Government or the ratepayers of the Shire of Harvey, have not been adequately addressed in the ERMP. It is anticipated that this matter will be further addressed in the Community Needs Study;
- concern was expressed that inadequate information is provided in the ERMP on the proposed access and egress points to the site and the anticipated road and plant noises which will be generated during the construction phase. The report fails to adequately address predicted traffic flows during the construction phase and the likely impact they will have on adjoining farmlands and residential areas;

- the report entitled "Traffic Aspects" which was to form a portion of the Worsley Siding Site Aluminium Plant ERMP fails to acknowledge the effects the Worsley Alumina Refinery had on the Mornington Road west of the Refinery access road. These incorrect assumptions have been carried forward into the Kemerton ERMP and therefore the credibility of the traffic study is questioned;
- the planning of the Australind By-pass Highway and its construction should be re-programmed to ensure that the construction workforce for the smelter has an alternate means of access to the site other than through the existing Australind townsite;
- the information on available infrastructure as detailed in Section 5.3.4 of the ERMP and proposed upgrading, on schools, etc., has been superseded by recent Government decisions and planning. Council will address this matter in great detail through its submission on the Community Needs Study;
- in Section 7.3.1 of the ERMP, the flow-on effect of the proposed smelter has been derived from data prepared for the Hunter Valley Smelter in New South Wales. Council queries the relevance of that data to the case in hand and questions whether or not those predictions were realised;
- the comment in section 7.5.3 of the ERMP stating:
"Planning for Australind would need to consider:
(a) an additional Primary School;
(b) construction of a Secondary School;
(c) provision of an Infant Health Nurse;
(d) provision of Child Care Facilities;
(e) provision of an upgraded Library; and
(f) upgraded facilities for community and sporting groups.

These needs may be exacerbated if the population grows in Binningup without the provision of social facilities. If Binningup and Australind are to develop in an orderly fashion, external assistance for Harvey Shire may be required".

This comment is totally supported by Council.

6.2.2.3 Economic Considerations

- physical infrastructure such as local and regional roads will be directly affected by the establishment of a smelter on the Kemerton site and therefore the creation or upgrading of those roads, to acceptable traffic standard, should be borne by the proponent which is developing the project;
- the table describing the construction inputs (ERMP Table 4.8) should be expanded to incorporate **all** construction materials and table should be modified to acknowledge normal construction procedures, e.g. the constituents for the concrete would be transported to the site and a mobile batching plant would be established in close proximity to the building activity;
- any information sheet distributed to the contractors should, in addition to pointing out matters of relevance to environmental protection, designate specific haulage routes approved by Council and the Main Roads Department;
- a Management Committee should be formed prior to the construction phase of the project to liaise on and resolve likely construction impacts, e.g. location of construction camps, condition of public roads, etc. Representatives of all participating local and State Government authorities plus the proponent and its construction engineers, should be represented. An independent arbitration system should be developed in the State Agreement Act to assess areas of conflict which cannot be resolved through normal conciliation practices;
- the Shire of Harvey requests that it be involved in the preparation of the State Agreement Act to ensure that adequate areas of compensation and arbitration have been provided for the ratepayers of the district;
- The State Agreement Act should provide the appropriate clauses to ensure that the plant is maintained in a condition which will enable current and future air emission standards to be met and it should contain appropriate penalty provisions should those standards be exceeded;
- provisions should be written into the State Agreement Act to dispose of cathode wastes by an agreed, environmentally sound method (to be resolved prior to plant start-up), and the cathodes should be disposed of by that method unless the company can demonstrate that alternate technology is more environmentally acceptable;
- the fact that the smelter provides an impetus to the Bunbury 2000 project and it consumes large volumes of natural gas, are not valid justifications for the continuation of the project;
- reference is made in the ERMP in several places (p.xiv, 5-13 and A102) to the predicted population for the Bunbury region at the year 2000). Figures of 50,000, 100,000 and 200,000 are quoted. The Final Environment Impact Statement should record the population for the Bunbury Region Planning Report.

6.2.2.4 Land Use

- the Shire of Harvey Town Planning Scheme No. 10 Amendment No. 10 documents will be altered to show a maximum aluminium production level of 230000 tonnes per annum. The boundary of the “Additional Use” area will also be amended to ensure that the 400 ha plant site is located within the final zoned area;
- section 3.3.2 in the ERMP should be amended to acknowledge that the plant site has an economic value through its potential for “Special Rural” and “Special Residential” development. The extent of urban development beyond the year 2035 has not been determined, however, it must be acknowledged that the Kemerton area is also good residential land, being well drained and having good foundation soils;
- the information shown on Figure 5.9 of the ERMP is inconsistent with the “Plan C” option for the Bunbury region and Council’s long-term planning objectives for the Australind locality;
- Section 3 in the ERMP does not provide sufficient detail to allow a comprehensive analysis of the alternate site options.

6.2.2.5 On-going Studies

- prior to the commencement of construction of the Aluminium Plant, the proponent and/or Government should release the findings of the proponent-funded Authority’s studies detailed in Section 1.7.2 of the ERMP to the public;
- the State Government should not take a decision on the development of a smelter at Kemerton until all the appropriate commissioned reports and studies have been concluded, made available for public comment, and the submissions have been considered.

6.2.2.6 Concluding Comment

- the Harvey Shire Council considers that it would be irresponsible of them to support the smelter project at this time with so many environmental issues still unresolved.

7. BIOPHYSICAL IMPACT ASSESSMENT

This Chapter of the Assessment Report addresses the likely impacts of the construction and operation of the proposed smelter on elements of the biological and physical environment of the Kemerton site and surrounding areas. The segregation of biophysical and social impacts is artificial, as the boundaries between the two areas are not distinct, and the interactions and the linkages between them are important. For convenience, however, social impacts are assessed in Chapter 8, and cumulative impacts and the interactions between biophysical and social impacts are discussed in Chapter 9.

7.1 CONSTRUCTION PHASE BIOPHYSICAL IMPACTS

This section addresses the biophysical impact of smelter construction. In the main it confines its attention to impacts directly associated with smelter construction. Impacts resulting from the construction of smelter-associated infrastructure are briefly addressed where they would impact on the smelter site or buffer area. The impacts associated with infrastructure construction are addressed further in Appendices C and D.

7.1.1 ON-SITE BIOPHYSICAL IMPACTS

7.1.1.1 Potential Site Constraints

The proponent has not undertaken detailed geotechnical and engineering investigation of the proposed site to determine whether it is a suitable site for the construction of an aluminium smelter. The ERMP indicates that this work would be undertaken in subsequent detailed planning. In the context of an aluminium smelter, as with many other developments, the extent and severity of environmental impacts will be considerably influenced by the location and characteristics of the smelter site and the degree of modification required to achieve necessary engineering design criteria. As such, the Authority believes that site-specific investigations, sufficient to determine whether or not the proposed site is suitable for the planned developments, should have been undertaken prior to the submission of the ERMP.

In this instance, the Authority notes that a recently completed detailed soil survey of the Kemerton area (undertaken by the CSIRO at the request of the Authority and funded by the proponent) indicates the presence of groundwater at depths of as little as 1 metre in summer (and undoubtedly less in winter) beneath the smelter site (Figure 17). These studies are discussed in Section 4.2 and Appendix B.

Experience with aluminium smelters in others parts of the world has demonstrated that for operational reasons a minimum separation of 4 metres and preferably more than 6 metres must be maintained between the reduction cells (pots) and the highest anticipated groundwater level. Similarly the anode coke furnace must be located at least 5 metres above the underlying groundwater. The ERMP recognises this constraint and states that "it is desirable that there be at least five and preferably more than eight metres between the watertable and the plant potroom level so that the underground platform portions of the electrified potrooms and the hot furnaces of the carbon bake remain dry". (Helleman, Section 3.3).

The Authority believes that the shallow groundwater on the smelter site thus constitutes a major constraint which will, at the very least, substantially change the site preparation requirements, imposing additional construction costs and impacts not addressed in the ERMP, and at worst could entail a change of site.

Neither the ERMP nor the proponent's responses to questions on this issue raised by the Authority, both before and during the public comment period, (and raised in public submissions) addressed this issue in detail. Rather, the proponent preferred to consider the results of the soil survey as preliminary, and proposed to regard these matters in the subsequent EMP, should they prove to be substantial. The Authority considers that this response is inappropriate.

RECOMMENDATION 2:

The EPA recommends that, in order to determine the suitability of the site for construction of a smelter, the proponent should undertake the following groundwater surveys:

- a comprehensive investigation of the Kemerton area; and
- a detailed investigation of the proposed smelter site.

The results of these surveys, which should form part of the proponent's overall engineering assessment of the site, should be reported to the EPA early in the detailed design phase of the project.

In general terms, there are several potential means of resolving the water table problem which are briefly discussed below:

- the water table could be lowered, either by improving drainage to the Wellesley River or through extraction of groundwater;

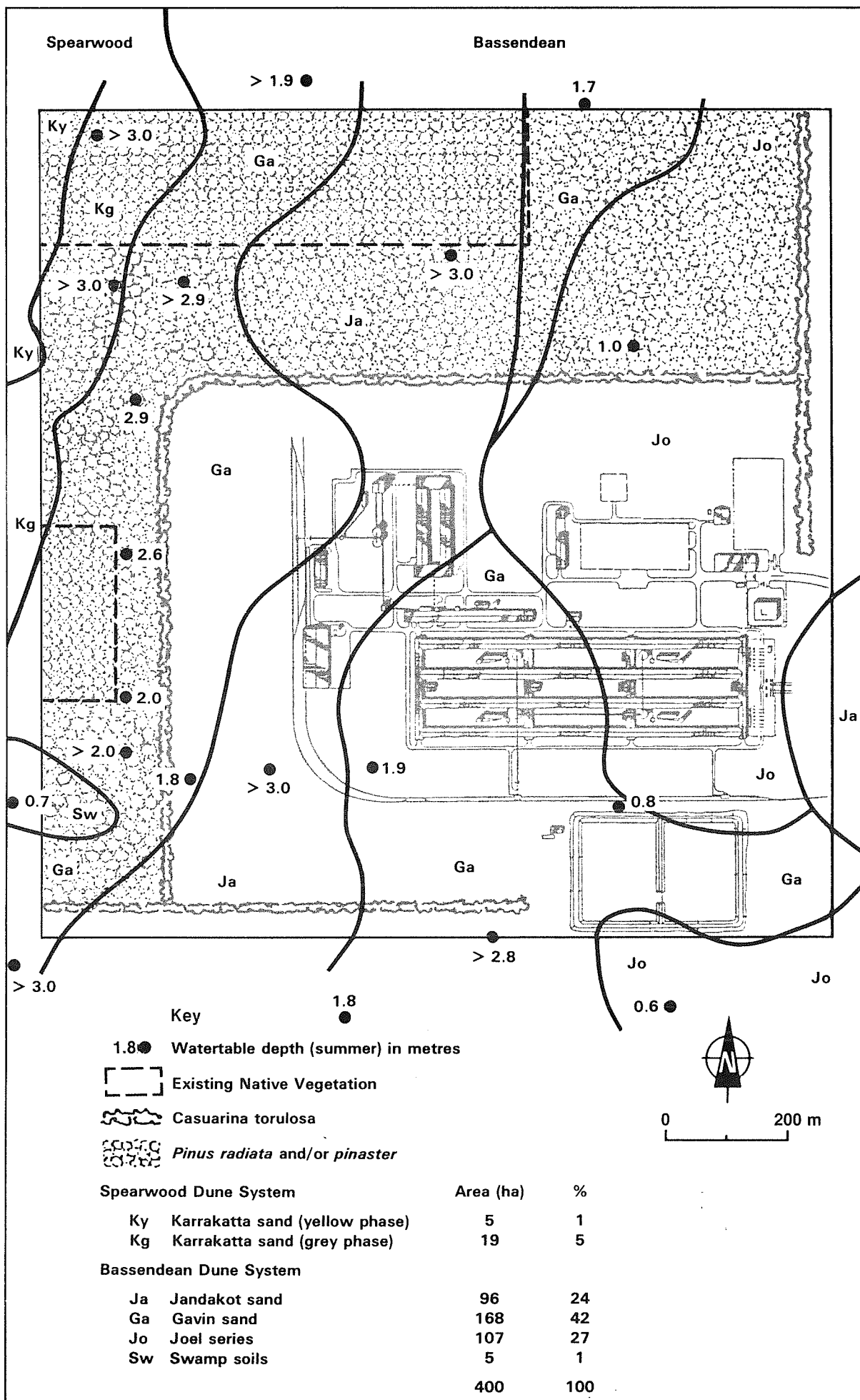


Figure 17 — Soil Types and Depths to Water Table (summer) for the Smelter Site.

- the potlines could be raised, either by providing a more substantial sand pad or by constructing the potrooms on piles, as has been done with the Gladstone smelter;
- a combination of lowering the water table and elevating the potrooms could be adopted; or
- the smelter site could be shifted within the Kemerton area to higher ground.

Each of these options carries with it its own environmental impacts.

Lowering the water table, if it is feasible, would clearly have implications for the wetlands and vegetation which is adapted to the existing water table regime. If a substantial reduction of the order of five metres below the potlines is necessary, this option may also have implications for the growth performance of the pines to be established in the buffer zone and hence on their function as a fluoride sink.

Raising the potroom on a substantial sand pad will necessitate the provision of substantial quantities of fill. It is estimated that raising the potrooms only, would require approximately 200000 cubic metres of fill for each metre of elevation. The soil survey of the smelter site indicates that the proposed potlines would be located entirely on Joel and Gavin sands which have water tables at average depths of approximately 1 and 1.5 metres respectively at the end of summer and perhaps a metre higher at the end of winter (Dimmock, 1985). These figures suggest that a minimum of approximately 1000000m³ of fill would be required to provide a 5 metre elevation. The proponent has indicated in the Supplement that it expects to obtain all its fill requirements from within the Kemerton area, with consequent implication for the off-site impacts during the construction phase. These implications are addressed further in Section 7.1.2.2.

The alternative of elevating the potrooms on piles would, of necessity, require a substantially stronger, more massive platform with associated increased concrete demands, and secondary impacts on traffic congestion and noise. These impacts, however, could be reduced by employing a concrete batching plant on site and supplying the raw material needs by rail. However co-ordination of early construction of the rail spur would be required to achieve this.

In respect of the change of site option, the Authority would view a shift in the proposed smelter site with concern. This assessment has been based on the construction of the smelter, with an east-west orientation, on the site identified in the ERMP. Many of the anticipated impacts, upon which this assessment of the proposal is based, are specific to the site and orientation proposed. This applies particularly to the predicted dispersal of fluoride air emissions and associated impacts. In this context the Authority notes that the present site was selected in order to maximise the containment of fluoride impacts within the buffer zone.

RECOMMENDATION 3:

The EPA recommends that a change in the specific site of the smelter, or a change in orientation of the potlines, would necessitate re-submission of details to the EPA to evaluate the change in potential impacts.

The Authority has identified shallow groundwaters on the proposed smelter site as a major engineering constraint. Other than in this respect the foundation conditions and normal earth works are not expected to cause any significant problems on the chosen site.

7.1.1.2 Site Clearance

The smelter buildings and associated infrastructure will occupy extensive areas within the 400 ha smelter site. A substantial portion, estimated at 150 ha in the ERMP, would be cleared to facilitate smelter development. Additional areas would be required to cater for road and rail transport links, gas and power corridors and other infrastructure.

Site clearing and recontouring to prepare level platforms for plant structures is the most obvious impact of the construction phase. The smelter site retains small remnants of native vegetation but has largely been cleared either to a parkland appearance or completely cleared and developed for agricultural purposes (Figure 10). In its original condition it represented jarrah-marri-banksia woodland with *Melaleuca* species comprising a major component in low-lying areas. The development site does not include any wetland communities, the main focus of conservation interest in the Kemerton area.

The jarrah-marri-banksia formation is still relatively well represented on the southern Swan Coastal Plain, and is conserved in Yalgorup National Park. The ERMP indicated that clearance of native vegetation would be limited to the loss of a 20 ha remnant but that the remnants in the west and north-west of the site would be retained. The proponent attached no significance to the loss of the 20 ha remnant.

The Authority considers that the description of the biophysical environment presented in the ERMP was superficial and that this has led to an inadequate assessment of impacts in the ERMP. In this context, it is understood that the remnant block of vegetation which would be cleared for construction of the smelter was not investigated in the flora and fauna surveys discussed in the ERMP. The largest known population of Skinner's pea (*Pultenaea skinneri*), a declared rare plant (Department of Fisheries and Wildlife, 1983) and a number of other restricted species are

known from a similar habitat near the south-eastern wetland, just south of the remnant block of vegetation (Blackwell and Cala, 1982).

The Authority acknowledges the proponent's proposal to undertake a more detailed survey of the remaining areas of native vegetation on the site, and to retain these areas wherever possible. These areas could form part of a valuable monitoring network providing information on the effects of fluoride in a Mediterranean ecosystem.

7.1.1.3 Dust and Sediment-Laden Runoff

The gentle terrain and porous sands found on the smelter site should minimise the potential generation of sediment-laden runoff and are inherently less prone to generating significant dust problems than many other soils. The proponent has indicated, however, that it will install a site drainage system and a sedimentation dam to prevent the escape of sediment-laden flows from the site, and proposes to regularly spray all trafficked areas to minimise dust.

RECOMMENDATION 4:

The EPA recommends that, in order to protect residents in surrounding areas, the proponent should undertake dust control measures wherever necessary to comply with the relevant National Health and Medical Research Council (NH & MRC) guidelines for inert nuisance particulates in ambient air. Furthermore, in controlling dust in the workplace, the proponent should comply with the NH & MRC occupational health guidelines for threshold limit values.

7.1.1.4. Construction Waste Disposal

The ERMP fails to address the disposal of wastes produced during the construction phase. Wastes produced are likely to consist of sewage and construction materials, including both solid inert building materials and chemical wastes, and will need to be disposed of by a variety of methods.

RECOMMENDATION 5:

The EPA recommends that the proponent takes the following actions for management of construction-phase wastes:

- **sewage should be stored in tanks and regularly pumped out for transport and disposal at established treatment plants or at approved liquid waste disposal sites, until such time as a package sewage treatment plant is in operation;**
- **solid building wastes should be disposed of in on-site pits to be progressively excavated, filled, and rehabilitated; and**
- **all other wastes produced should be disposed of in a manner satisfactory to the relevant authorities.**

7.1.1.5 Afforestation and Site Management

The proponent proposes to establish substantial forested areas within the 400 ha smelter site, to act as the first line of fluoride absorption. As the ERMP correctly explains the closer that trees can be planted to a fluoride source and the taller the trees, the more effective they are in reducing airborne fluoride concentration.

The impact of fire on the forest plantation is only briefly mentioned in the supplementary information provided by the proponent. The trees suggested for this plantation, *Casuarina torulosa* and *Pinus radiata* or *P. pinaster*, are however killed by relatively mild fires. Because a major fire could virtually eliminate the fluoride absorption capacity of affected areas of the buffer, fire is an important consideration in the planning and management of forest plantations on the smelter site and the surrounding land (Section 11.1 and Appendix E).

The ERMP places most emphasis on establishing forested areas to the north and west of the smelter, and directions of the greatest fluoride drift. Plantations along the southern and eastern boundaries appear to constitute little more than visual screens despite the presence of fluoride sensitive agricultural lands relatively close to the eastern boundary.

RECOMMENDATION 6:

The EPA recommends that, within the proposed smelter site, the proponent should establish as early as possible prior to construction:

- **tree plantations throughout the site to absorb fluoride, except where development precludes this; and**
- **forest fire management measures in conjunction with those of the Department of Conservation and Land Management for the Kemerton area (see also Recommendation 27).**

7.1.1.6 Aesthetics

The visual impact of any object is determined by a range of factors, including:

- size, shape and texture;
- background from viewpoint;
- colour relative to surroundings;
- distance between object and viewpoint; and
- intervening obstructions.

A project such as a smelter is bound to have some visual impact, simply because of its dimensions. As indicated in the ERMP, the four potrooms would each be 800 m long, 20 m wide and 22 m high. In addition to these dominant structures, associated buildings would also be visually intrusive. In particular, each of the four primary dry scrubbers is proposed to have a 46 m high stack, as would the anode baking furnace scrubber. The green carbon building indicated in Figure 4.4 of the ERMP appears to be at least as tall as these stacks.

The ERMP, in Section 7.4.6, indicates that the smelter will not be visible from the Old Coast Road but will be from the east. Figure 7.6 in the ERMP illustrates two cross sections showing project visibility. This figure is very conservative due to the substantial vertical exaggeration (x25) and the visual impact may be less than is illustrated. Screens of trees will not only be established within the smelter site, but the Conceptual Land Management Plan proposes tree planting along nearby road corridors.

As a consequence, the major aesthetic impact would, in time, be limited to views from the South West Highway and the Darling Scarp. The proponent believes that this impact will not be high because of the viewing angle, the viewing distance and the forested dune background to the smelter. In the case of the Highway, only the scrubber stacks will be visible whereas the whole complex will be apparent when viewed from vantage points on the scarp. Those residences located on the face of the scarp will, therefore, have their outlook intruded upon by the smelter.

In the short term however, before trees planted around the smelter are sufficiently large to provide an effective screen, the design and cladding of the smelter structures will be major determinants of the degree of visual impact. These aspects will continue to be important in minimising the visual impact of views from the South West Highway and Darling Scarp.

Recommendation 6, in Section 7.1.1.5 addresses the need for early tree planting on the smelter site.

The Authority suggests that the design and cladding of the smelter structures be such as to minimise visual impacts.

7.1.2 OFF—SITE BIOPHYSICAL IMPACTS

The off-side impacts associated with the construction phase are in part associated with the provision of services and infrastructure to the smelter. These issues are addressed in more detail in Section 11.2 and Appendices C and D. They are considered here only in so much as they impinge on the smelter site and buffer zone. In most cases the impact of the service corridors to the smelter will be limited to minor additional clearing along the alignments. A 330 kV switchyard supplying power to the smelter would require a 6 ha area adjacent to the smelter site, in conjunction with an additional 6 ha on the smelter site itself.

7.1.2.1 Construction Camp

The proponent did not provide detailed information on siting of the proposed construction camp or camps. It is likely, however, that at least one camp catering for up to 800 people could be located in the Kemerton area. This would introduce a number of potential biophysical impacts as a result of:

- site clearing operations;
- the provision of road access and services to the camp;
- the potential to introduce *Phytophthora cinnamomi* and other plant pathogens to the site;
- the disposal of sewage, domestic refuse and other effluents generated in the camp; and
- the recreational pressures exerted by those living in the camp.

In the absence of information on the size, siting and provision of infrastructure services and management of the construction camp(s), it is not possible to adequately assess this aspect of the project.

It is considered, however, that the wetlands and to a lesser extent remnants of relatively intact native vegetation are of conservation significance and should be protected, where possible, from impacts associated with the construction camp(s). While much of the existing native vegetation (with the exception of the wetlands) would eventually be cleared and the areas planted to pines under the Conceptual Land Management Plan, the vegetation would have an important function, as a fluoride sink, until such time as the pines are of sufficient size to be effective in this role.

RECOMMENDATION 7:

The EPA recommends that the proponent should consult with and obtain the approval of all relevant authorities, on the siting, establishment and management of the camp(s), associated facilities (including sewage treatment plant) and access corridors. Should the proposed site lie within the buffer zone, then it will be necessary to involve the Department of Conservation and Land Management.

7.1.2.2 Fill Requirements

The high water table, identified earlier in this Chapter, raises the possibility that large quantities of sand fill may be needed to elevate the potlines and anode bake furnace; substantial quantities of fill may also be required in constructing infrastructure, in particular the railway.

Although there is no shortage of sand in the Kemerton area which could be used for fill, the use of this resource would need to be carefully planned, managed and rehabilitated, if it is not to have major impacts on the subsequent use of these areas for pine plantations. Given the proposed role of the plantation as a fluoride sink and as a timber producing forest, the rehabilitation of any sand extraction site and its preparation for planting must be given high priority.

The ERMP has failed to address in any detail a possible requirement for large volumes of fill. Given the quantities potentially involved (approximately 200000 m³/metre of elevation), very substantial excavations are likely. The proponent has indicated in the Supplement that any additional fill would likely be obtained from surrounding Government-owned land.

RECOMMENDATION 8:

The EPA recommends that if foundation requirements are such that the proponent needs to excavate and remove large amounts of earth, and/or if the proponent proposes other than a standard cut-and-fill operation on the site, these should be referred to the EPA for environmental assessment.

7.1.2.3 Noise

The construction of an aluminium smelter would generate noise. The ERMP does not adequately discuss the issue of construction phase noise or how this noise can be controlled.

Sources of noise during the construction phase would include:

- on-site earth moving equipment;
- concrete batching plant (if one is located on or near the site);
- internal transportation and truck movement;
- fabrication; and
- off-site, on-road and other truck movements.

The ERMP states that "on the basis of ten items of earthmoving equipment operating at one time, a total sound power level of 123 dB(A) would be generated" (Helleman, p.A185). The proponent then suggests that this level would attenuate* to 40 dB(A) within approximately 2 km of the proposed smelter site (Figure 16). No details of the analysis undertaken to arrive at this figure are given in the ERMP. However, experience elsewhere indicates that four kilometres may be a more realistic estimate.

The proponent appears not to have measured existing background noise levels in the area. Although the Neighbourhood Annoyance Regulations of the Noise Abatement Act specify 40 dB(A) level as a reasonable daytime outdoor noise level in a country setting, it is likely that the actual background noise level in the surrounding area is much lower and the intrusion of a 30-40 dB(A) noise level is therefore likely to lead to complaints, particularly if construction activities were to be continued at night.

The Authority also notes that the acoustic amenity of people living along the roads, where the construction material is to be transported, might also be affected.

There are a number of methods by which the total quantity of noise generated during the smelter construction phase could be reduced or controlled. The Authority believes that responsibility lies with the proponent to discuss this matter, in detail, in the EMP and to propose an acoustic management programme which would ensure that the amenity of the local area is not affected because of the noise generated during the construction phase. Possible methods include the following:

- reduction in noise emitted by the equipment used. Equipment is currently available which would generate up to 20% less noise than that stated in the ERMP;
- restriction of working hours;
- provision of bund walls or other noise screening methods;
- provision of modifications in existing local dwellings so as to reduce noise impact;

- examination of methods by which total truck movements could be reduced; and
- the use of roads designated for truck movements to ensure that truck movements occur along the highways or are confined to roads where noise impacts can be managed.

The proponent will need to comply with prevailing noise control legislation and regulations in the preparation of the acoustic management programme in the EMP.

7.1.2.4 Recreation Impacts

The Kemerton area and surrounding region contain a number of ecologically sensitive environments, notably the fragile coastal dune systems, Leschenault Inlet and relatively accessible wetlands in the Kemerton area. These and other areas are likely to experience an increase in recreational use associated with people brought into the region to work on construction of the smelter.

7.2 OPERATIONAL PHASE IMPACTS

7.2.1 AIR POLLUTION

Emissions to the atmosphere from an aluminium smelter contain gaseous and particulate fluorides, sulphur dioxide, carbon dioxide, carbon monoxide, polyaromatic cyclic hydrocarbons, chlorine, carbon and tar vapour. The purpose of this Section of the Assessment Report is to evaluate the impacts of air pollutants from the proposed aluminium smelter.

The characteristics of the emission sources of air pollutants from a smelter are such that low concentrations in ambient air (in the microgram per cubic metre range) of fluoride and sulphur dioxide are typical. High concentrations would not occur, even under adverse atmospheric conditions, e.g. during inversions). Therefore this assessment considers the environmental impacts of long-term, low-concentration (chronic) exposures of fluoride and sulphur dioxide.

7.2.1.1 Criteria for Impact Assessment

To determine the potential for deleterious environmental impacts of air pollutants from the proposed smelter at Kemerton, it is important that relevant criteria for assessment are adopted. The Authority considers that the air pollutants from a smelter with potential to damage ecosystems and human health are gaseous fluorides and sulphur dioxide. The relevant criteria for these are discussed below.

The following guidelines for fluoride were proposed by the Air Pollution Control Council of WA (1983):

- where superficial visual damage to vegetation can be tolerated, the concentration of gaseous fluoride should not exceed 0.5 micrograms per cubic metre ($0.5 \mu\text{g}/\text{m}^3$), measured as hydrogen fluoride and averaged over three months;
- to give overall protection to vegetation, regardless of normal stress, the concentration of gaseous fluoride should not exceed 0.2 micrograms per cubic metre ($0.2 \mu\text{g}/\text{m}^3$), measured as hydrogen fluoride and averaged over three months;
- to protect plants, including the most sensitive species, from visible injury, the concentration of gaseous fluoride should not exceed 0.1 micrograms per cubic metre ($0.1 \mu\text{g}/\text{m}^3$) measured as hydrogen fluoride and averaged over the growing season.
- to protect dairy cattle (the most sensitive domestic animals), the average fluoride content of forage should not exceed $40 \mu\text{gF/g}$, expressed as fluoride on a dry weight basis, for any consecutive period of twelve months, or exceed $60 \mu\text{gF/g}$ for each month for more than two consecutive months.

In considering the adoption of a criterion for the average gaseous fluoride concentration which should be contained within the buffer area, the Authority has taken cognisance of the Air Pollution Control Council Guidelines. It also recognises that much of the natural vegetation within the buffer area will be cleared and planted to pines.

On this basis, in defining criteria, the Authority has placed emphasis on the need to protect sensitive agricultural land uses in areas surrounding the buffer. It also notes that the Air Pollution Control Council (1983) considered that:

"The actual application on a long term limit, whether 0.2 or $0.5 \mu\text{g}$ (gaseous fluoride)/ m^3 , could depend upon specific circumstances and relate to negotiation or redress for vegetation damage."

An annual average gaseous fluoride concentration of $0.3 \mu\text{g}/\text{m}^3$ is equivalent to an annual average concentration of $35\text{-}40 \mu\text{g/g}$ fluoride in forage on a dry weight basis (Appendix H). It should however be noted that this relationship is approximate and may be altered somewhat by factors such as wind patterns, rainfall, and high local concentrations of particulate fluorides.

The Authority has accordingly adopted the criterion that the average annual gaseous fluoride concentration of $0.3 \mu\text{g}$ should be contained within the buffer area. It considers that this criterion will provide a high level of protection to nature vegetation, though in times of stress sensitive species may suffer some superficial visual damage.

A number of public submissions expressed concern about the apparent lack of consideration given to particulate fluorides in the ERMP. The ERMP states that this is because:

“standards normally apply only to gaseous fluoride, as the particulate form is generally only sparingly soluble and has only very limited impact on its surroundings” (Helleman, Section 7.11).

The environmental impacts of particulate fluorides have been considered and the following points are relevant:

- particulate fluorides vary from being slightly soluble to virtually insoluble in water;
- the bulk of the particulates generated are normally deposited within 1-2 km of an aluminium smelter;
- particulate fluorides remain on the outside surface of leaves and some fluorides enter the plant. They are washed off by rainfall and are removed by mechanical action in a leaf canopy. Because of the above they have a less significant effect on vegetation than gaseous fluorides; and
- once deposited on vegetation, particulate fluorides may be consumed by grazing animals, although they are not absorbed as readily as gaseous fluorides because of their lower solubility.

Considering the above, the Authority is satisfied that most of the particulate fluorides would be deposited in the Government-controlled buffer zone area. The potential effects of particulate fluorides should be considered in any land management plan, especially if grazing is proposed within this area. The Authority concludes that the potential effect of particulate fluorides in areas outside the Kemerton area can be disregarded and that it is appropriate to model ground level concentrations of gaseous fluorides only.

Sulphur dioxide (SO₂) is a less toxic air pollutant than fluoride. Amongst the most conservative long-term standards proposed for sulphur dioxide are those of the World Health Organisation (WHO, 1979).

The Kwinana Air Modelling Study (Department of Conservation and Environment, 1982) recommended the following ambient air quality criteria to the WA Air Pollution Control Council as guidelines for the protection of human health and ecosystems:

Averaging Period	Sulphur Dioxide Concentration (in microgram per cubic metre)	Source
Annual	40-60	WHO, 1979
24 hour	100-150	WHO, 1979
1 hour	500	Victorian Government Gazette No. 63, 1981

The Authority has used these guidelines as a basis for assessing whether and where deleterious impacts of SO₂ are likely to occur.

7.2.1.2 Dispersion of Fluorides

The ERMP states that about 230 tonnes of fluoride per annum will escape from the smelter, diffuse and be spread by local winds. The dispersion mechanisms were discussed in the ERMP, and presented by a set of predicted isopleths (lines joining points of equal concentration) for ambient fluoride concentrations. This prediction of ground level concentrations resulting from emissions of the smelter was carried out using a computer model specifically designed to accommodate the characteristics of an aluminium smelter. This model, the Buoyant Line and Point Source (BLP) model, is recommended for use for the assessment of air pollution impacts from proposed smelters by the United States Environmental Protection Agency (US EPA).

The meteorological data available are a critical input to the BLP model. The Authority was initially concerned whether the meteorological data available were adequate and appropriate. Three sources of meteorological data were identified as possibly being suitable for use in the prediction of fluoride dispersion. These were:

- wind speed and wind direction data from the network of anemometers installed as part of the Bunbury Airshed Study;
- measurements of wind speed, wind direction, solar radiation and air temperature which were made at the Kemerton site; and
- data from the Glen Iris Base Station near Bunbury consisting of wind speed and direction measured at 27 metres, wind speed at 10 metres, standard deviation of wind direction at 27 metres, temperature difference over the height interval 10 to 27 metres, long wave radiation, solar radiation, dewpoint temperature at 10 metres, air temperature at 10 metres, soil temperature at 1 centimetre, soil heat flux at 1 centimetre, rainfall and barometric pressure.

The data used for modelling were selected using the following criteria:

- accurate measurements of as many meteorological variables as possible that were related to the modelling of dispersion of air emissions;

- the data, quality and recovery were high;
- the site of data measurement was representative of and as close as possible to the location of the proposed smelter; and
- the data were of at least 12 months' duration.

These criteria were applied to the meteorological data sources available, and it was concluded that the Glen Iris data were the most appropriate to use. The proponent was then advised to use these data for the dispersion modelling, and the Authority independently verified the proponent's modelling by running the BLP model itself, using assumptions identical to those of the proponent. A comparison of the available data, and the results of the verification modelling studies are presented in Department of Conservation and Environment Bulletin No. 203 which also elaborates on the discussion below.

Two major assumptions were adopted by the proponent for its modelling of fluoride dispersion. These were:

- values for decay rates for atmospheric fluoride for both wet and dry removal processes were assumed; and
- the smelter plume is able to penetrate atmospheric inversions lower than 150 m, and is completely contained within inversions greater than 150 m in height.

These assumptions are discussed further in Appendix 6 of the ERMP and in Department of Conservation and Environment Bulletin No. 203. The Authority confirmed that the proponent's model results could be reproduced when the same assumptions were applied, then investigated the proponent's assumptions as to their appropriateness.

The Authority's modelling adopted a more conservative 100 m boundary layer height. The Authority then re-ran the BLP model using the Glen Iris data and adopting the following more conservative assumptions:

- the smelter's plume could not penetrate any day-time inversion;
- at night, the vertical dispersion of the plume was not impeded by any boundary layer structure;
- a slightly different classification scheme to that adopted in the ERMP was used for atmospheric stability determination;
- a more complex mechanism was introduced to account for the removal of fluoride from the atmosphere; and
- no wet (or rain related) removal of fluoride was considered.

The predicted ground level fluoride concentration isopleths resulting from the above assumptions are shown in Figure 18, and compared with those of the proponent.

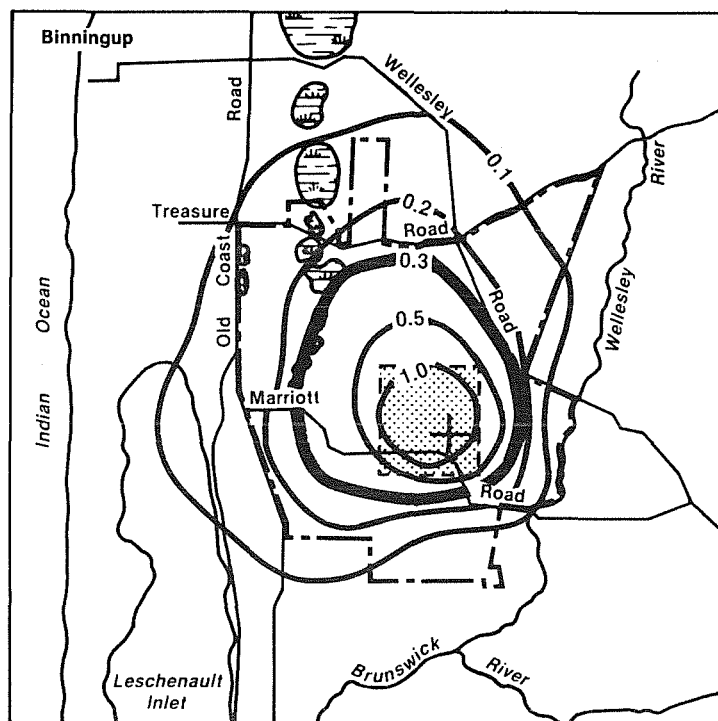
Comparison of the two sets of isopleths predicting annual average gaseous fluoride concentrations shows that the resulting contours are not significantly different. The isopleths of 0.1 microgram gaseous fluoride per cubic metre are further from the smelter in the Authority's results than those reported in the ERMP. This trend is reversed for gaseous fluoride concentrations greater than 0.2 micrograms per cubic metre. Both approaches have resulted in similar areas contained within the 0.3 microgram per cubic metre isopleth. The reasons for these differences are discussed in Department of Conservation and Environment Bulletin No. 203.

Another comparison between the proponent's and Authority's fluoride dispersion modelling is shown in Figure 19, where the three-month rolling average gaseous fluoride concentration isopleths are illustrated. In this case there are slight differences between the proponent's and Authority's modelling results, and these differences reflect the adoption of the differing assumptions mentioned above.

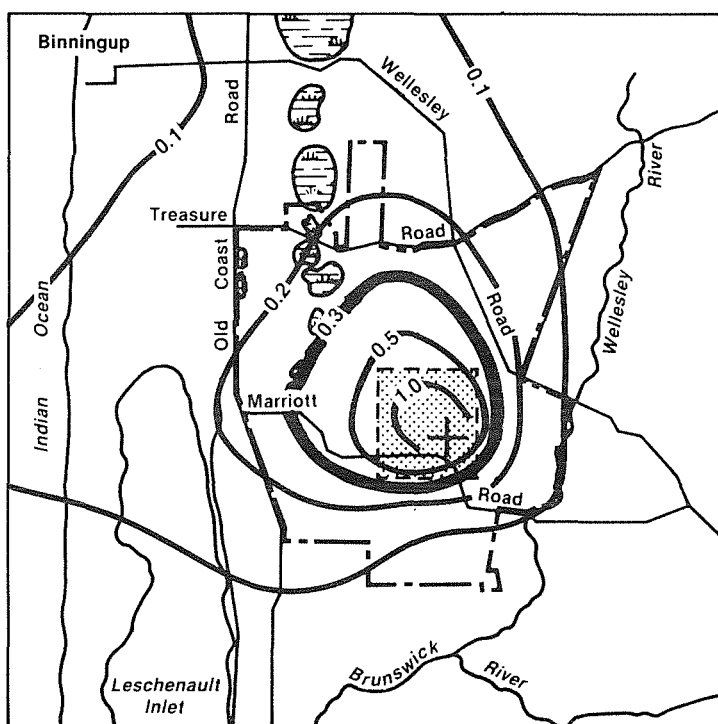
Figure 20 shows the proponent's predicted annual concentration isopleths for total fluoride (gaseous and particulate fluoride combined). This simulation was not verified by the Authority, however the Authority accepts this prediction as a reasonable representation of the likely extent of total fluoride distribution from the proposed smelter.

Some submissions from the public expressed concern that the "sea breeze effect" analysed in the Kwinana Air Modelling Study (Department of Conservation and Environment, 1982) may be operative at Kemerton. The term "sea breeze effect" refers to an inhibition of vertical atmospheric mixing near the land-sea interface. Pollutants discharged at low altitude into the sea breeze near the coast might be mixed close to the ground and cause localised fumigation, rather than being subjected to adequate upward mixing and dispersion. The "sea breeze effect" weakens with increasing distance inland, and atmospheric mixing depths increase in a similar way.

The Authority is of the view that the proposed smelter has low enough rates of emission, and is sufficiently far inland (7 km from the coast) for the adequate dispersion of atmospheric fluoride emissions. The BLP model incorporates the "sea breeze effect", and has been run under conservative assumptions which ensure that the results obtained constitute a worse-than-expected case.



A



B

Key



Smelter Site



Forestry/Recreation development

—0.9— Isopleths of predicted ground level fluoride concentration in $\mu\text{g}/\text{m}^3$



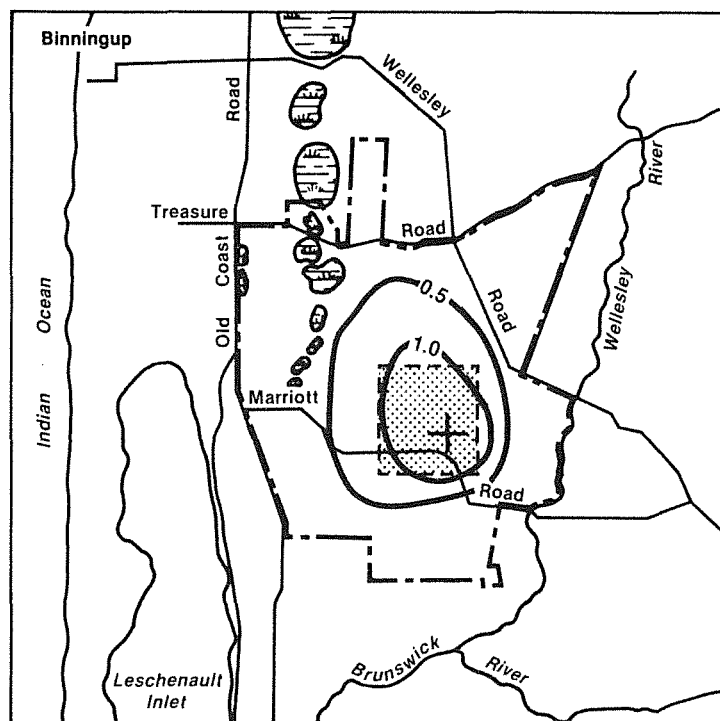
0 4 km

Figure 18 — Predicted Annual Average Gaseous Fluoride Concentration Isopleths from the Smelter (assuming an annual emission of 230 tonnes fluoride). Source: ERMP

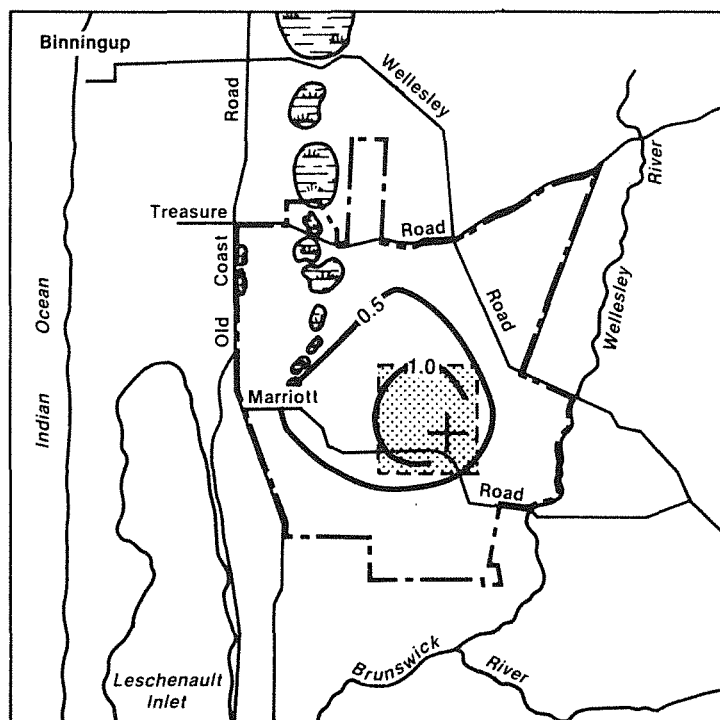
a) proponent's model

b) Authority's model

Explanation: The area enclosed by $0.3\mu\text{g}/\text{m}^3$ isopleth predicted by the proponent's model is 1475ha and by the Authority's model is 1012ha. The difference between the two results from each model having different assumptions. The main feature of the EPA model was the gaseous fluoride decay mechanism.



A



B



Figure 19 — Predicted Three-Monthly Rolling Average Gaseous Fluoride Concentration Isopleths from the Smelter (assuming an annual emission of 230 tonnes fluoride). Source: ERMP

(a) proponent's model

(b) Authority's model

Explanation. The area enclosed by the $0.5 \mu\text{g}/\text{m}^3$ isopleth predicted by the proponent's model is 1160ha and by the Authority's model is 1012ha. The difference between the two results is due to the fact that each model had different assumptions.

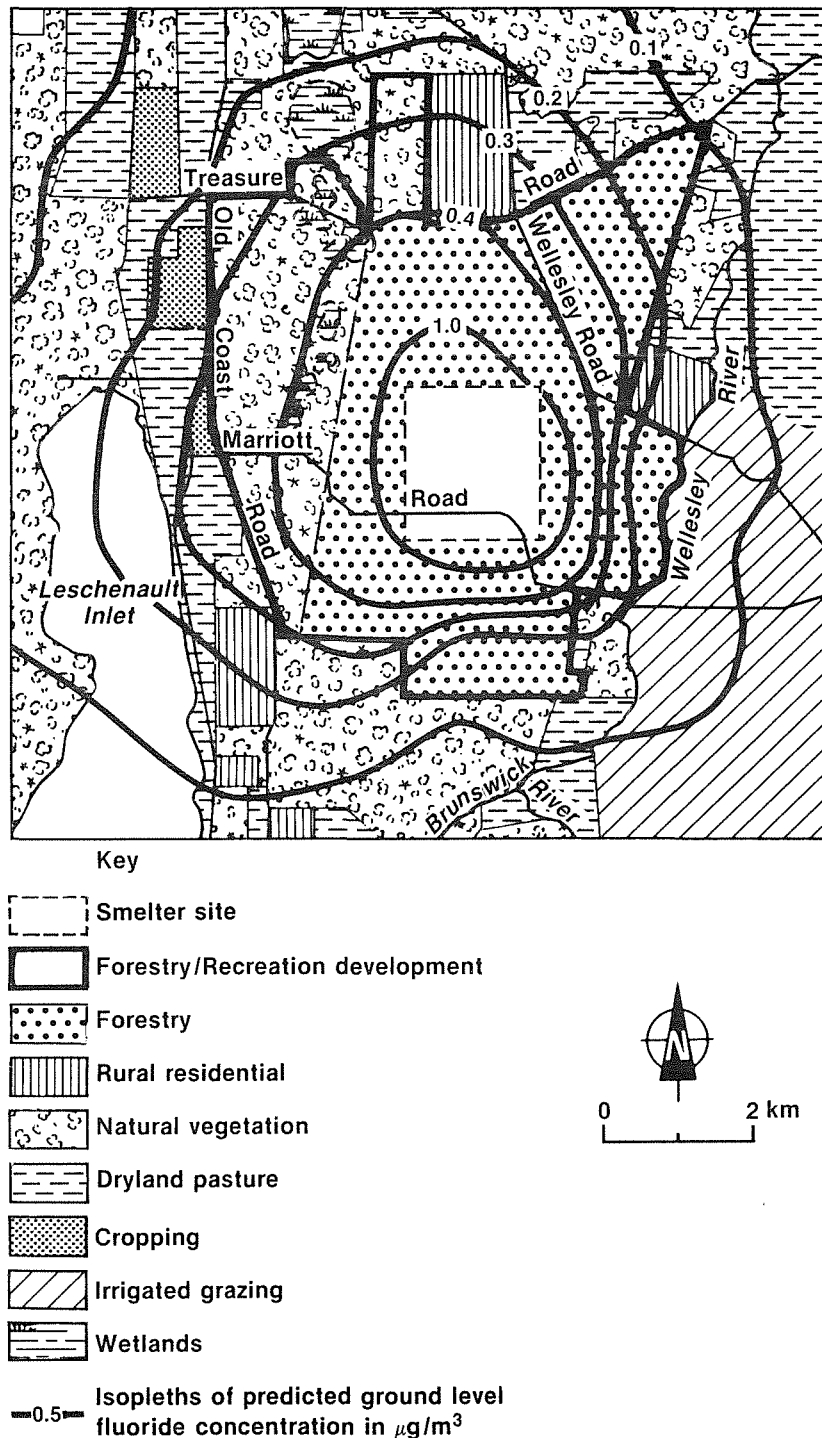


Figure 20 — Predicted Annual Average Concentrations of Total Fluoride (Gaseous and Particulate) from the Smelter.

7.2.1.3 The Effects of Smelter Orientation and Location on the Dispersion of Air Pollutants

It should be noted that the location of the proposed smelter site was chosen, in part, to minimise the effects of fluoride emissions on the surrounding areas.

If the proposed east-west orientation of the potrooms were changed it would alter the long-term patterns of fluoride dispersion shown in Figures 18-20, and might necessitate a new dispersion modelling study, and a reassessment of the environmental effects of fluorides on the surrounding areas. As sulphur dioxide is emitted primarily from the smelter stacks a change in orientation of the potrooms would not influence the distribution of sulphur dioxide emissions.

Relocation of the whole smelter complex within the Kemerton area would shift the origin of the predicted fluoride isopleths shown but not their spatial distribution about the origin, provided that the currently proposed alignment of potrooms was not altered. The areas receiving significant fluoride loadings would of course change, and changes to the boundaries of the proposed buffer zone may be necessary.

Any change of elevation of the smelter up to approximately 10 metres would not significantly affect the predictions of fluoride dispersion shown in Figures 18-20.

The Authority considers that any change of potroom orientation, or any relocation of the smelter would require further assessment of the predicted patterns of fluoride dispersion and their effects (Recommendation 3).

7.2.1.4 Air Pollution Under Atypical Conditions

There are four situations under which predicted long-term ground level concentrations of air pollutants would be exceeded for short periods of time. These are during start-up of pots, during periods of short-term adverse meteorological conditions, under conditions of power failure or power reduction to the smelter or during partial or complete failure of the smelter's pollution control equipment.

It is difficult to assess the likely severity of environmental impacts from any of the above events, and the Authority would expect that the best possible means are employed by the proponent to mitigate and manage air pollution.

These matters should be addressed in the proponent's Environmental Management Programme (EMP).

7.2.1.5 Global Distribution of Fluorides

Fluorides are widely distributed in the natural environment and occur in rocks, soils, surface water, groundwater, air, plants and animals. They are released as particulates (dust) or as a gas from many industrial facilities including coal-fired power stations, steel plants, phosphate fertiliser works, brick, tile and glass works, as well as from aluminium smelters. Fluoride is very toxic and may accumulate in plants, animals and the bones and teeth of humans (Appendix I).

7.2.1.6 Fluorides and Ecosystems of the Kemerton Area

The fluoride dispersed over the Kemerton area (Section 7.2.1.2) would interact in a variety of ways with the waters, soils and organisms of the ecosystems.

These interactions are summarised in Figure 21, which shows the linkages among the major components of an ecosystem, and the effects of fluoride on each component. Atmospheric emissions and dispersion of fluorides reduce air quality, and deposition of fluoride may reduce the fertility of soils and cause direct damage to sensitive plant species.

Soil fertility may be affected by fluoride toxicity in a variety of ways, including:

- inhibition of decomposers, which break down dead animal and plant matter, releasing essential minerals in a suitable form for plant uptake and growth. Decomposers include a variety of invertebrates, including earthworms and litter organisms, and bacteria and fungi;
- fluoride toxicity of mycorrhizae, which are specialised fungi associated with plant roots which assist with nutrient uptake, particularly in nutrient-deficient soils; and
- reduction of nitrogen fixation. This process is carried out in soils by the symbiotic bacterium *Rhizobium* spp., or by free-living or symbiotic cyanobacteria (blue-green algae), which convert atmospheric nitrogen to ammonia, a valuable source of nitrogen for plant growth. Some types of higher plants known to fix nitrogen in this way are legumes (peas, clovers, lucerne, acacias), casuarinas, blackboys (*Xanthorrhoea* sp.) and cycads (*Macrozamia* sp.). Non-symbiotic nitrogen fixers also occur in wetlands. These processes are indicated in Figure 21.

Herbivores eating plants may suffer fluoride toxicity (fluorosis), and in some cases, carnivores which eat herbivores may also experience fluoride toxicity. This is particularly so for animals which eat fluoride-enriched insects and other invertebrates. The specific impacts likely would depend on the pathways by which fluoride is transferred, and the sensitivity of the organisms or ecosystem processes to fluoride.

The components of ecosystems of the Kemerton area most susceptible to fluoride toxicity, and the storages and movement of fluoride through these systems, are shown schematically in Figure 22.

Kemerton wetlands and Leschenault Inlet, and terrestrial ecosystems include irrigated and dryland agriculture, native forests and the proposed forestry plantations. Similar processes of nutrient and fluoride cycling occur in all ecosystems, although the species of animals, plants and micro-organisms, soil and sediment types, and rates of cycling differ among ecosystems.

Aquatic sediments and soils store the largest amounts of fluoride in the environment, but differ in their capacity to bind fluoride in biologically innocuous form. Fluoride is chemically reactive, and is readily bound to clays, compounds of iron, aluminium and calcium and to organic matter. These soil and sediment fluoride storages are shown in Figure 22, and the variation in the proportion of water-soluble (biologically active) fluoride in the soil reflects the variability of the fluoride-binding capacities of the soils of the Kemerton area. Bassendean Sands have a very low fluoride-binding capacity, while that of Karrakatta Sands is much higher.

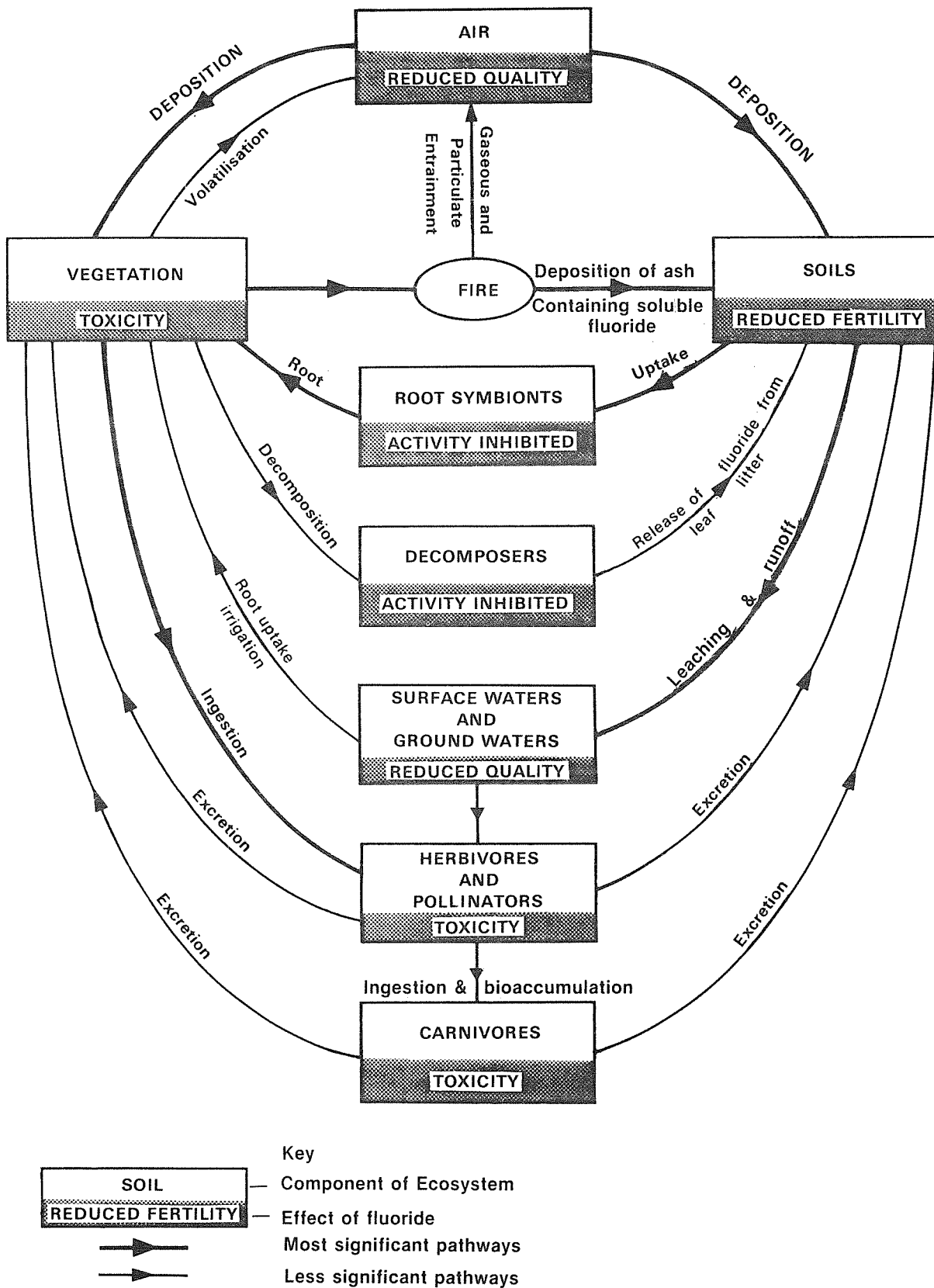


Figure 21 — Major Pathways for Fluoride in Ecosystems.

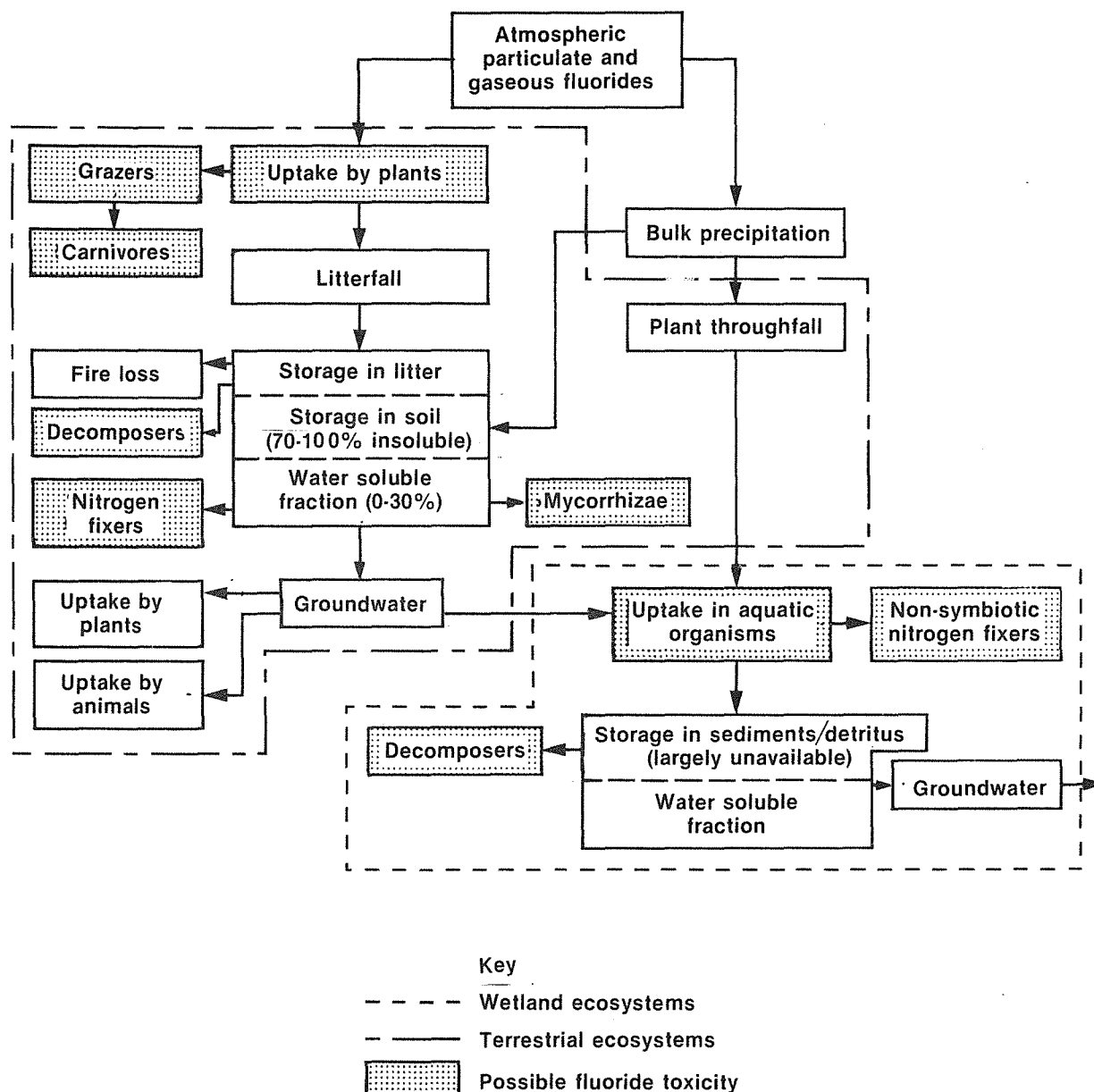


Figure 22 — Schematic Representation of Fluoride Movement Within Ecosystems of the Kemerton Area.

The stippled compartments shown in Figure 22 are those in which fluoride is known to have, or might have, deleterious effects on agricultural or native ecosystems. The effects of fluoride on many plant and domestic animal species are well known, and the likely impacts of airborne fluorides from the proposed aluminium smelter are discussed in detail in Section 7.2.1.7 to 7.2.1.15, and summarised in Section 7.2.1.18. Effects of fluoride on human health are discussed in Section 7.2.1.16.

7.2.1.7 Effects of Fluoride on Domestic Animals

The main sources of fluoride to animals are food, water, mineral supplements, drugs, soils or sediments ingested by the animals. Inhalation and skin absorption of airborne fluoride account for negligible amounts. Domestic animals show a wide range of sensitivity to fluorides and the most sensitive animals are considered to be dairy heifers.

A number of submissions referred to possible adverse effects of fluoride on livestock. The order of decreasing sensitivity of domestic animals is dairy cattle, beef cattle, sheep, horses, pigs, chickens and turkeys. Standards have been developed overseas to protect dairy cattle from economic damage based on limiting the fluoride concentration in forage. These standards are briefly described in Appendix I. The basis for these standards is that if the most sensitive domestic animals (dairy cattle) are protected, all other domestic animals will also be protected. It is essential that all sources of fluoride in the animals' total diet are taken into account when the risk of unacceptable exposure is being considered. There are some uncertainties in relation to the concen-

trations of fluoride that would accumulate in dryland pastures in Western Australia during early summer, and there are suggestions that an annual mean concentration of 40 $\mu\text{gF/g}$ will not protect all dairy cattle from economically deleterious effects under all circumstances. However, taking these matters into consideration, and provided other aspects of the total fluoride diet are considered, it is not anticipated that economically harmful effects on domestic animals will occur in the area outside of the 0.3 $\mu\text{g/m}^3$ annual average isopleth zone of total fluoride shown in Figure 20. Inside this area it is possible that sensitive domestic animals, in particular cattle and sheep, could be harmed if grazed continually and it is important that these animals are monitored and carefully managed to ensure that this does not occur (Appendix I).

7.2.1.8 Effects of Fluoride on Native Fauna

Fluoride effects on native mammals are similar to those which occur in cattle (described in Appendix I). Little is known about the sensitivity of wild animals to fluoride, but it is commonly assumed that standards which protect dairy cattle would also protect other grazing wildlife. A number of studies have suggested that fluoride is accumulated along food chains, but there is little evidence in relation to the ecological consequences of this bio-accumulation. Fluoride has been used commercially as an insecticide and has been shown to alter the growth and reproduction of some insect species feeding on plants containing high fluoride is accumulated along food chains, but there is little evidence in relation to the ecological consequences of this bio-accumulation. Fluoride has been used commercially as an insecticide and has been shown to alter the growth and reproduction of some insect species feeding on plants containing high fluoride concentrations (Lawrence, 1981). Major outbreaks of pest insects have occurred in forests around aluminium smelters and it has been suggested that this is as a result of fluoride suppression of predator activity (Alcan Surveillance Committee, 1979).

Bird populations around some old aluminium smelters have been reduced but the causes have not been specifically identified. Birds of commercial importance such as chickens and turkeys are relatively tolerant of fluoride.

The area of impact of fluoride on wildlife is expected to be confined to the Kemerton area (within the 0.3 $\mu\text{g/m}^3$ annual average isopleth of gaseous fluoride). As this area will be subject to major habitat modification if the pine plantation proceeds, any effects of fluoride are expected to be negligible.

7.2.1.9 Effects of Fluoride on Bees

The ERMP did not address the question of impacts on the apiculture industry, even though bees are known to be sensitive to fluoride. The Authority is aware that a considerable number of private apiary sites exist on land close to the smelter. In addition, marri, which is believed to be sensitive to fluoride, is an important source of spring-summer nectar and pollen for the local apiculture industry.

Experience in Europe with old smelters incorporating poor emission controls has shown that bees may be sensitive to fluoride. The Alcan smelter in the Hunter Valley of NSW has established bee hives at distances of 1 km and greater from the smelter. Careful monitoring has shown no adverse effects of fluoride on bees or on honey production, or evidence of contamination of honey with fluoride. Based on this experience, and a number of scientific studies, no effects of fluoride on bees, or honey production, and no contamination of honey is expected when hives are located in the area outside of the 0.3 $\mu\text{g/m}^3$ annual average gaseous fluoride isopleth shown in Figure 20. However, the changes in land use proposed in the Conceptual Land Management Plan will reduce the available jarrah/marri woodland and may reduce honey production for those hives which previously depended on this source of nectar and pollen.

7.2.1.10 Effects of Fluoride on Plants

Airborne fluorides are accumulated by plants, especially in leaves. Fluoride dusts may settle on the leaf surface but they only slowly enter the leaf, and can be washed off the leaf surface by rainfall or by spray irrigation. Fluoride gases may enter the leaf and are less easily removed. Fluoride deposited on soils may be bound by soil factors such as aluminium, iron, calcium and others. However, some of the soils in the Kemerton area may have very low concentrations of these factors, so that some fluoride deposited on soils may be taken up by roots, or washed down to the groundwater. Fluoride is not very mobile in plants, so that only a small proportion of the amount taken up by roots may be transported to above-ground parts, and fluoride in leaves is not transported to fruit, grain, or root tubers (Weinstein, 1977). Consequently while leafy vegetables such as spinach may increase in fluoride concentration, other vegetables and fruit have little fluoride in edible parts.

Plants vary considerably in their sensitivity to fluorides. Very sensitive plants may be injured by continuous exposure to fluoride concentrations in air as low as 0.1 $\mu\text{g/m}^3$ over several months. Other plants may be exposed to 1000 times this concentration without visible injury. The plants most susceptible to visible injury are grapevines, young conifer foliage, gladiolus and some cultivars of sorghum. Some groups of eucalypts such as bloodwoods (e.g. marri) are

relatively sensitive to fluoride, but ironbarks are resistant. Jarrah may be intermediate in fluoride resistance. Further information on the sensitivity of plant species to fluoride is provided in Appendix I and Table 9.

Table 9 Relative sensitivity of some common plant species to Atmospheric Fluoride

	Fluoride Sensitivity		
	Sensitive	Intermediate	Resistant
Apple		*	
Apricot		*	
Bean			*
Cabbage			*
Capsicum		*	
Carrot			*
Cauliflower			*
Celery			*
Cherry		*	
Chrysanthemum			*
Clover (White)		*	
Corn (Sweet)#	*		
Cucumber			*
Eggplant			*
Eucalyptus — marri	*		
— jarrah		*	
Gladiolus	*		
Grapevine	*		
Grapefruit		*	
Lemon		*	
Lucerne			*
Marigold			*
Orange		*	
Pea (garden)			*
Peach (foliage)		*	
Peach (fruit)	*		
Pear			*
Pine # (young needles)	*		
(old needles)			*
Plum #	*		
Potato			*
Potato (sweet)		*	
Rose		*	
Ryegrass			*
Sorghum #	*		
Strawberry			*
Tomato		*	
Wheat		*	

Applies to some varieties or species only.

Some fruit may be sensitive to fluoride. Fruit of some peach varieties may be damaged by fluoride at concentrations as low as $0.3 \mu\text{g}/\text{m}^3$ after continuous exposure for eighty days. Leaves may not be visibly affected by concentrations several times greater (MacLean *et al.*, 1984).

Visible injury to foliage and changes of economic significance are often not related. For example, visible injury to grapevine leaves occurs at very low atmospheric fluoride concentrations, much lower than are necessary to alter yield or quality. However, wheat is resistant to leaf injury, but changes in yield occur before visible injury to leaves.

Pasture species are relatively resistant to fluoride. They may accumulate fluoride concentrations which may have deleterious effects on animals which consume forage, after exposure to much lower concentrations of fluoride in air than would cause changes in growth, yield or to other aspects of forage quality.

A great number of scientific studies, and experience with fluoride emission sources in Western Australia and in other areas of Australia, enable the following assessment of the likely effects

of fluoride on plants:

- at average gaseous fluoride concentrations which exceed $0.1 \mu\text{g}/\text{m}^3$ for several months during the period of plant growth, some minor visible injury could occur in very sensitive cultivated species such as grapevines and gladiolus. It is believed that some of these are planted in the rural residential areas to the north of the site. The Authority notes that the proponent has undertaken to replace garden plants shown to be affected by fluoride with fluoride-tolerant species or varieties (Appendix K).
- at annual average concentrations of gaseous fluoride which exceed $0.3 \mu\text{g}/\text{m}^3$ minor visible injury may occur to leaves of sensitive native species such as marri and blackboy (*Xanthorrhoea*). Exposure to these concentrations could also produce fluoride concentrations in pastures and forage crops which exceed levels recommended to maintain the health of dairy cattle. There may be visible injury to leaves of some varieties of sorghum, and young foliage of some conifers, although whether economically significant effects would occur is not known. If sensitive varieties of peaches are continuously exposed to this concentration during the later stages of fruit development, fruit damage may occur;
- at annual average concentrations which exceed about $0.5 \mu\text{g}/\text{m}^3$ of gaseous fluoride, moderate amounts of foliar injury would occur in a range of sensitive cultivated and native species. These are listed in Table 9.

In the assessment of these effects the Authority notes that the isopleth for annual average gaseous fluoride concentration of $1.0 \mu\text{g}/\text{m}^3$ is entirely contained within the land owned by the proponent, and the isopleth for annual average gaseous fluoride concentrations of $0.3 \mu\text{g}/\text{m}^3$ is largely contained within the intended Government-controlled area (Figure 18). The Government has indicated in its Conceptual Land Management Plan for the area that forestry practices compatible with these concentrations of fluoride will be developed for this area, including the selection and planting of genetic stocks of trees which are resistant to these concentrations of fluoride (Forests Department, 1985).

7.2.1.11 Effects of Fluoride on Agricultural Ecosystems

The responses of pastures and fodder crops were discussed in Section 7.2.1.10. The studies being conducted by the Department of Agriculture for the Authority will provide information which will assist with the management of pastures and fodder crops. In these areas, some of the marri which provides shade to grazing animals may show injury to leaves, but tree death is not expected below annual average atmospheric concentrations of at least $0.5 \mu\text{g}/\text{m}^3$ of gaseous fluoride. The annual average $0.5 \mu\text{g}/\text{m}^3$ isopleth is largely encompassed within the smelter site.

Cropping areas exist largely to the west and north-west of the site and are outside the $0.3 \mu\text{g}/\text{m}^3$ annual average gaseous fluoride isopleth. Although it is possible that some sorghum varieties grown at about this concentration could develop minor visible symptoms of fluoride injury, leaf injury is not expected at lower concentrations. The Authority has been advised that sorghum is not widely grown in the area, and that the cultivation of sorghum-type summer fodder crops in irrigated areas is being encouraged. In relation to specific crop varieties there is no information on the concentrations at which yield and quality may be affected by fluoride exposure. The irrigated areas lie outside the $0.5 \mu\text{g}/\text{m}^3$ isopleth.

It is possible that sensitive varieties of peaches exposed to $0.3 \mu\text{g}/\text{m}^3$ of gaseous fluoride for about three months during the fruit development stage could show fruit injury, but no areas of peach cultivation are known to exist inside this isopleth.

Some very sensitive plant species such as grapevines and gladiolus in home gardens in the rural residential area to the north of the site may develop minor symptoms of leaf injury in the area encompassing annual average gaseous fluoride concentrations of $0.1 \mu\text{g}/\text{m}^3$.

7.2.1.12 Effects of Fluoride on Pine Plantations

The pine plantations to be developed at the site was discussed in the Conceptual Land Management Plan and is to be managed in a manner compatible with anticipated atmospheric fluoride concentrations in the area of between 0.3 and $0.5 \mu\text{g}/\text{m}^3$ as annual averages of gaseous fluoride. Although genetically suitable pine stock would be selected to maintain productivity (i.e. tree growth) at these fluoride concentrations, this does not mean that there would be no injury to foliage.

Any stock grazing within the agro-forestry area will require careful management to ensure that effects of fluoride do not occur (Appendix I).

7.2.1.13 Effects of Fluoride on Native Forests

Native forests within the Government-controlled area will be largely replaced by pines as outlined in the Conceptual Land Management Plan (Forests Department, 1985). Appendix E discusses the fluoride impacts on remnant native vegetation. Indirect effects of fluoride are possible by means of adverse effects on nutrient uptake or cycling, as a consequence of toxic effects on soil micro-organisms. These are amenable to management. Possible interactions of fluoride with

insects and microbial diseases cannot be predicted with current knowledge. Beyond the 0.3 $\mu\text{g}/\text{m}^3$ isopleth forests have already been disturbed by farming and other activities, and minor visible injury to sensitive native species (e.g. marri and blackboy [*Xanthorrhoea*]) could occur at annual average gaseous fluoride concentrations as low as 0.2 $\mu\text{g}/\text{m}^3$ where there are other ecological stresses. Beyond this zone, the Authority believes that no direct or indirect ecological effects would occur because of the low amounts of fluoride that would be added to the environment by the smelter.

The Authority suggests that the best stands of jarrah and marri in Kemerton be retained and monitored by the proponent in order to characterise the effects of fluoride on these important species and facilitate assessment of long-term subtle effects of fluoride on natural forest ecosystems.

7.2.1.14 Effects of Fluoride on Marine Ecosystems

A number of public submissions commented on the need to protect Leschenault Inlet from adverse effects of emissions. Leschenault Inlet is 4 km from the proposed smelter site. There appears to be no detailed information on the rate of exchange of waters in the northern end of the Leschenault Inlet, although work by Glover (1980) and by Hearn *et al.* (in press) indicates that, with the possible exception of shallow portions of the extreme northern end, exchange is likely to be fairly rapid. The hypersaline conditions that develop in the northern end of the Leschenault Inlet during summer as a result of evaporative loss, also suggest that high exchange rates may not be maintained for this end of the Inlet.

Modelling carried out by the Department of Conservation and Environment indicates that deposition rates of fluoride on the surface of the water body are expected to be about 0.05 g/m^2 per year. Calculations show that this would increase the fluoride concentration of inlet water from about 1.4 to 1.45 ppm, ignoring tidal flushing. Allowing for assumptions of increases in groundwater fluoride concentrations (Section 7.2.2.4) which may enter the Inlet, and a small mixing rate of tidal water, the Authority has concluded that fluoride concentrations would remain well below the concentration of 5 ppm, below which no deleterious effects have been shown to occur in marine ecosystems (US EPA, 1980).

7.2.1.15 Effects of Fluoride on Freshwater Ecosystems

A number of freshwater wetlands exist to the north-west and south-east of the smelter and the Authority believes that these are the most significant biological resources in close proximity to the smelter site. It is believed that these wetlands are a surface expression of the unconfined water table. These wetlands lie outside the 0.3 $\mu\text{g}/\text{m}^3$ annual average gaseous fluoride isopleth, although the Kemerton wetlands and the south-eastern wetland are adjacent to this isopleth. At these concentrations of fluoride in air it seems unlikely that the wetland vegetation, predominantly *Melaleuca* species, will be affected by fluoride. The BLP Model indicates that fluoride deposition to the surface of the wetlands would be a maximum of 0.1 g/m^2 per year which would increase the fluoride concentration of wetland waters by an average of about 0.1 ppm. This increase in concentration is not expected to harm aquatic organisms.

Current groundwater fluoride concentrations in the area are about 0.3 ppm. This may increase slightly as a result of fluoride emissions from the smelter operations (Section 7.2.2.4). The Authority has concluded that although there may be a small increase in fluoride concentrations in the water, sediments, flora and fauna of these wetlands, there would be no deleterious effects, as no adverse effects of fluoride have been observed in freshwater ecosystems when the concentration of fluoride in water is below 1.5 ppm (US EPA, 1980). Some public submissions observed that it is possible that some accumulation of fluoride could occur in the food chains of the wetland organisms. The implications of this are not known and monitoring and management should be considered.

7.2.1.16 Effects of Fluoride on Human Health

A number of public submissions expressed concern about the potential of emissions to adversely affect public health. Fluoride may have beneficial or harmful effects on human health depending, among other things, on the quantity of fluoride ingested. Beneficial effects on oral health may result from the ingestion of a few milligrams (mg) of fluoride per day (WHO, 1984). Fluoride is added to public water supplies for this reason. Harmful effects may result from the ingestion of high doses of fluoride. People living around a modern smelter should absorb negligible amounts of fluoride by inhalation or skin absorption (Appendix I). People living in the vicinity of old smelters without emission controls have shown a number of fluoride-related health problems (Smith and Hodge, 1979).

Employees, particularly potroom workers, absorb considerably more fluoride by inhalation than would nearby residents. Regulations have been developed and are checked by monitoring of the air in potrooms to ensure that workers are not exposed to excessive amounts of fluoride. As a further check on industrial hygiene, monitoring of urine of potroom workers should be carried out to indicate the margin of safety, ensuring that occupational hygiene is maintained at all times.

These are discussed by the World Health Organisation (1984).

Some leafy vegetables grown by residents within about 3 km of the smelter site may increase in fluoride concentration because of smelter emissions. The concentration of fluoride in the food consumed is reduced by food preparations, such as the discarding of outer leaves which contain most of the fluoride, and washing. The edible parts of other fruit and vegetables should contain negligible concentrations of fluoride.

Some public submissions also referred to the potential for contamination of rainwater by fluoride. Rainwater collected from roofs close to the smelter may be expected to increase in fluoride concentration from washout of fluoride from air by rain, and deposition of fluoride directly onto the roof. Normally rainwater has very low fluoride concentrations, about 0.1 mg/L, but tap water in fluoridated town water supplies has 1 mg/L. The final concentration of fluoride in the tap when rainwater has been collected from a roof in an area near a fluoride emission source is difficult to predict. The Authority believes it is essential that these water supplies be monitored, and other supplies arranged if fluoride concentrations exceed 1 mg/L. The proponent has undertaken to do this (Appendix K).

7.2.1.17 The Environmental Impacts and Dispersion of Sulphur Dioxide

Sulphur dioxide is produced by the oxidation of sulphur in the petroleum coke used to manufacture anodes. It is largely evolved in the pots and emitted from the dry scrubber, which are not effective in scrubbing sulphur dioxide. Smaller amounts are emitted through roof vents and the anode bake stack. The proposed aluminium smelter would emit approximately 5400 tonnes per annum of sulphur dioxide into the atmosphere.

The ERMP addressed the issue of sulphur dioxide emissions in a preliminary and incomplete manner, and a number of public and government department submissions also made this observation. The Supplement included the proponent's modelled predictions of sulphur dioxide dispersion from the smelter.

There was public concern that the quantity of sulphur dioxide emission from the smelter alone, or in combination with sulphur dioxide emitted by other sources in the region, may be a detrimental impact on the surrounding area.

The proponent used the BLP model, and adopted the following assumptions:

- removal of sulphur dioxide from the air was not taken into account because of the lower chemical reactivity of sulphur dioxide;
- emissions released above the boundary layer during stagnant conditions at night were assumed to disperse vertically as well as horizontally and allowed to reach the ground; and
- the plumes from the dry scrubbers could penetrate inversions up to 150 metres in height.

The Authority has undertaken its own investigations on the dispersion of sulphur dioxide. Firstly, it verified the proponent's methodology by reproducing its results.

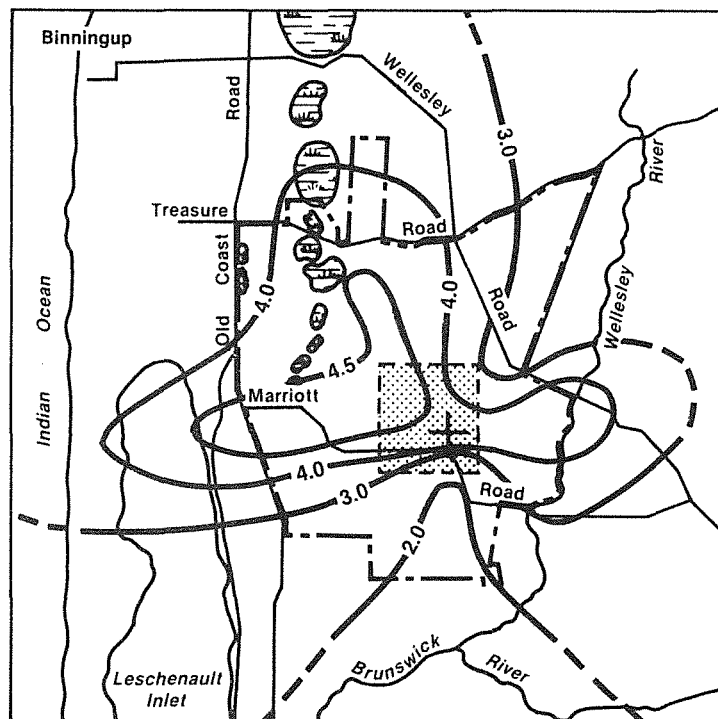
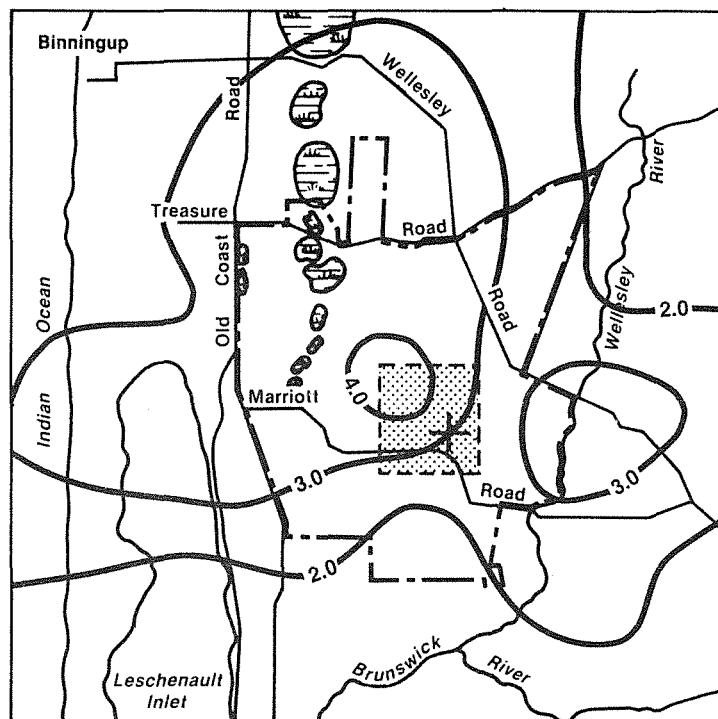
Secondly, it has undertaken a modelling exercise using the BLP model and changing one of the above assumptions. This change was that the plume from the dry scrubbers could penetrate inversions up to a height of 100 metres. The Authority believes that this figure is more conservative than that assumed by the proponent. The isopleths resulting from the Authority's and the proponent's modelling of the sulphur dioxide emissions are shown in Figure 23. For further details of the methodology see Department of Conservation and Environment Bulletin No. 203.

Sulphur dioxide concentrations predicted by the Authority are higher than those predicted by the proponent. This reflects the more conservative approach taken by the Authority. These predicted concentrations can be compared to the long-term goal of the World Health Organisation which is an annual average concentration of 40 to 60 $\mu\text{g}/\text{m}^3$ (WHO, 1979). The Authority did not undertake a cumulative sulphur dioxide modelling, or incorporate the modelling results of studies from other areas beyond that shown in Figure 4. However, the Authority believes that, based on the extrapolation of predicted isopleths from Kemerton, the annual average sulphur dioxide concentration at Australind will be increased by less than 1.0 microgram per cubic metre.

Similarly, sulphur dioxide concentrations resulting from the Bunbury Power Station, SCM Chemical Ltd titanium dioxide plant and CSBP are expected to contribute to an increase of less than 1 microgram per cubic metre to the predicted annual average at the smelter site.

Taking the above into account, particularly the present low total SO_2 loading in the Bunbury region airshed, the Authority concludes that:

- while large quantities of sulphur dioxide emissions would always be of concern to the Authority, in this case the relatively low quantity of sulphur dioxide emitted is such that a local or regional sulphur dioxide air pollution problem would not occur;
- independent Authority predictions of sulphur dioxide levels from the smelter are comparable with those submitted by the proponent;
- there is no justification to require the proponent to scrub the SO_2 from the smelter air emissions;



Key



Smelter Site

Forestry/Recreation development

—0.9— Isopleths of predicted ground level fluoride concentration in $\mu\text{g}/\text{m}^3$



0 4 km

Figure 23 — Predicted Annual Average Sulphur Dioxide Concentration Isopleths from the Smelter
Source: ERMP

(a) proponent's model

(b) Authority's model

Explanation. The consortium model assumed the sulphur dioxide plume was trapped by inversion layers higher than 150 metres. The Authority's model was more conservative and assumed that the sulphur dioxide was trapped by inversion layers higher than 100 metres.

- the quantity of SO₂ deposited on the local area would not cause contamination of groundwater or raise the sulphur content of the soil to an extent which would have a detrimental impact; and
- the increase in SO₂ ground level concentrations due to all the regional SO₂ sources would only slightly increase the predicted SO₂ isopleths shown in Figure 23. However, this quantity is so far below the most conservative World Health Organisation SO₂ standard that the Authority does not believe that SO₂ will have adverse effects, and accepts the conclusions of the proponent on the likely impacts of sulphur dioxide.

Sulphur dioxide may have the effect of increasing the response of plants to other pollutants but these effects only begin to occur at SO₂ concentrations in the order of 100 µg/m³, very much higher than those predicted to result from the smelter.

7.2.1.18 Summary of the Environmental Effects of Air Pollutants

This assessment has considered the predicted patterns of dispersion and the environmental effects of fluoride and sulphur dioxide in areas beyond the proposed buffer zone surrounding the smelter. It has demonstrated that these areas will be subjected to annual average gaseous fluoride concentrations of less than 0.3 µg/m³, and annual average total fluoride concentrations of less than 0.5 µg/m³, provided that emissions do not exceed a maximum of 230 tonnes of total fluoride per year (Figures 18-20).

It also assumes that the predicted annual emission of approximately 5400 tonnes of sulphur dioxide is not exceeded, and that the average annual ground level concentrations of SO₂ shown in Figure 23 are of the correct magnitude.

The Authority concludes that:

- human health will not be affected by fluorides, provided that the fluoride body burdens in smelter workers are monitored regularly, and that rainwater used for drinking does not exceed 1 mg/L of fluoride;
- domestic animals outside the proposed buffer zone are not expected to be detrimentally affected by fluorides provided that they do not receive additional fluoride in dietary supplements;
- domestic animals inside the buffer zone, particularly cattle and sheep, will need to be monitored and carefully managed to prevent fluorosis;
- detrimental effects of fluoride on wildlife would be expected to be confined to the area within the 0.3 µg/m³ annual average isopleth for gaseous fluoride;
- no detrimental effects of fluoride on bees, honey production or honey quality is expected outside the area contained within the 0.3 µg/m³ annual average gaseous fluoride isopleth;
- minor visible injury to sensitive, cultivated plant species may occur in areas in which the annual average gaseous fluoride concentrations exceed 0.1 µg/m³;
- minor visible injury to sensitive native plant species may occur in areas in which annual average gaseous fluoride concentrations exceed 0.3 µg/m³;
- pastures and forage crops may accumulate fluoride in concentrations deleterious to dairy cattle in areas in which annual average gaseous fluoride concentrations exceed 0.3 µg/m³;
- moderate amounts of foliar injury and possibly some mortality may occur in a range of sensitive cultivated and native plant species exposed to concentrations which exceed 0.5 µg/m³;
- subtle effects of fluoride on nitrogen fixation, nutrient cycling or mycorrhizae could occur within the 0.3 µg/m³ gaseous fluoride annual average isopleth, but are amenable to management;
- there are unlikely to be any deleterious impacts of fluoride on Lechenault Inlet from the smelter;
- no directly toxic effects of fluorides on wetland plants and animals are likely, although there may be an accumulation of fluoride in wetland food chains, and the implications of this are not known;
- predicted emissions of sulphur dioxide are low, and will not cause a local or regional air pollution problem, nor will they cause "acid rain", or pollute soils and groundwater; and
- deleterious synergistic effects of sulphur dioxide and fluoride on plants and ecosystems are not expected, because the predicted maximum concentrations of sulphur dioxide are well below those at which such effects are known to occur.

7.2.1.19 Emission Limits for the Proposed Aluminium Smelter

The Authority has determined the likely extent of adverse effects of air pollution from the

smelter (see Sections 7.2.1.1.-7.2.1.18) under the conditions stated in ERMP, namely total fluoride emission rates of 1 kg F/tAL, 230 tonnes of total fluoride emitted annually to the atmosphere and a ratio of 1:1 particulate:gaseous fluorides.

The proponent stated in the ERMP that the proposed smelter will be designed and operated in such as way as to:

- minimise source emission levels;
- maximise pollutant stream capture efficiency;
- optimise treatment or reuse of collected pollutant streams; and
- appropriately manage the smelter site.

The assessment of the impact of fluoride emissions in this Assessment Report was based on an annual emission rate of 1 kg of fluoride per tonne of aluminium produced with the smelter operating at its full capacity of 230000 tonnes per annum.

Information presented by the proponent and the results of studies undertaken for the Authority show that, at this level of emission, air pollution impacts from the proposed smelter would largely be contained within the buffer area. The Authority considers that management procedures for the Kemerton area can be developed to ensure that the environment does not receive more than the predicted fluoride deposition rates and to minimise adverse effects. However, the Authority is not confident that management procedures can be developed if deposition was greater than predicted. Consequently, to exceed total fluoride emissions of 230 tonnes per annum may significantly increase ground level fluoride concentrations, and invalidate this assessment of fluoride effects.

The Authority has reviewed annual average fluoride emission rates for modern smelters in Australia and elsewhere in the world. This review shows that annual average total fluoride emission rates of less than 0.75 kilograms of total fluoride per tonne of aluminium smelted are being achieved, even by smelters which were completed in the late 1970s (Figure 24).

Consequently it believes that a rate of 0.75 kilograms of fluoride per tonne of aluminium produced is achievable by modern well-managed aluminium smelters and it is desirable that this be achieved to ensure an adequate margin of protection for the surrounding ecosystems.

The Authority recognises that even during normal operations, fluctuations in electrical load or abnormal conditions such as anode effects (see Section 5.3.1) will influence fluoride emissions. Similarly, under the atypical conditions that occur during smelter start-up, or in the event of a partial failure of the smelter's pollution control equipment or power supply, an emission rate of 0.75 kilograms per tonne would probably be exceeded. The variation in smelter emission rates on a month by month basis is illustrated in Figure 24.

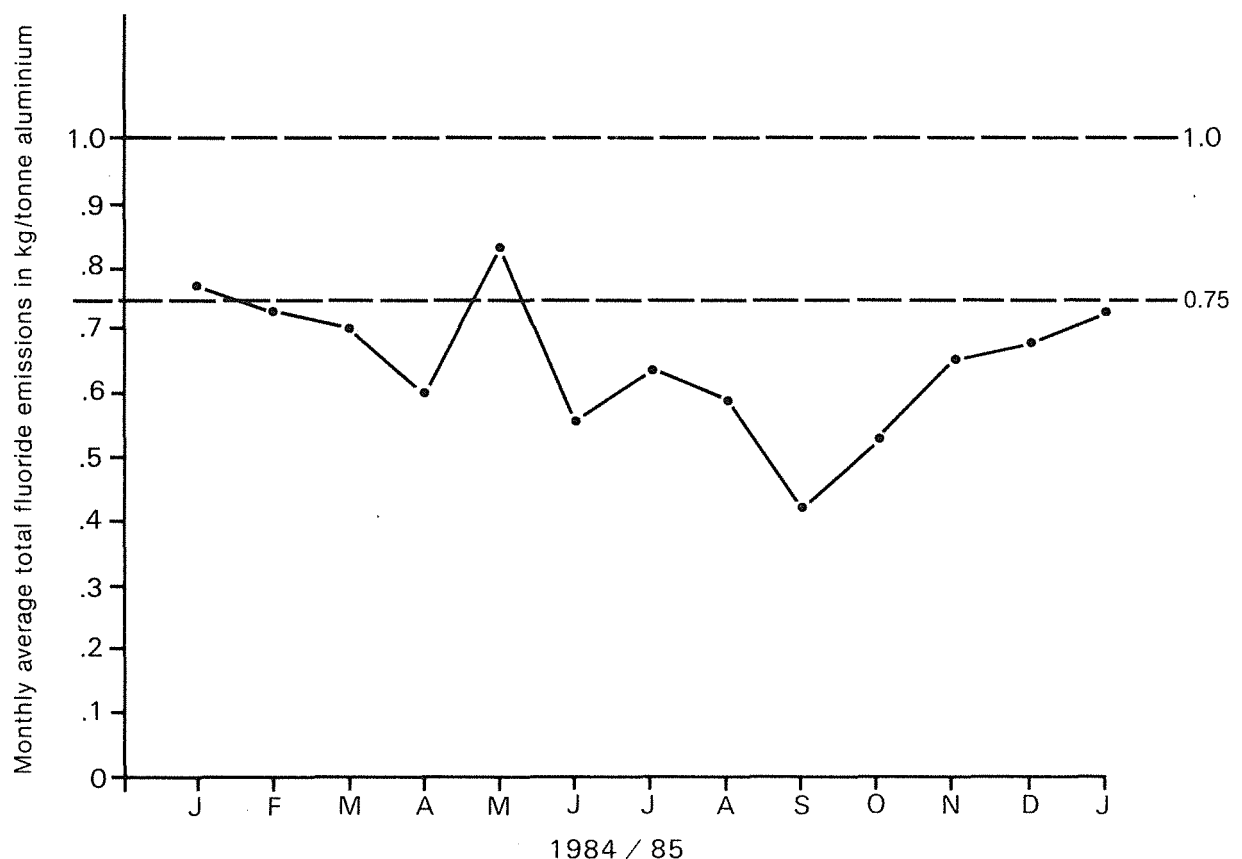


Figure 24 — Total Fluoride Emission Rates from Tomago Aluminium Smelter from January 1984 to January 1985. (Emissions during the start-up period preceding this would have been higher)

Based on its belief that an emission of 230 tonnes of fluoride from the proposed smelter can be managed, the Authority has decided that, to allow for the contingencies referred to above and normal variation in emission rates, an annual rate of 1 kilogram of fluoride per tonne of aluminium produced and a maximum emission load of 230 tonnes of total fluoride per annum should be adopted.

The Authority notes that the smelter is a “scheduled premises” under the Clean Air Act and as such may not operate until issued with a licence by the Minister for the Environment.

RECOMMENDATION 9:

The EPA recommends that:

- **an annual emission rate of 1.0 kilogram of total fluoride per tonne of aluminium produced shall never be exceeded;**
- **an emission rate of 0.75 kilograms of total fluoride per tonne of aluminium produced should be set as an objective; and**
- **irrespective of the size of the smelter, it should be restricted to a maximum emission load of 230 tonnes of total fluoride per annum.**

The Authority notes that emissions from a smelter can only be maintained at a low level when all personnel are well trained and motivated. This can be assisted by ensuring that:

- staff be trained through an operator training programme prior to start-up, with the training emphasising the need to maintain control equipment in an efficient working condition and removal of the minimum number of covers from any pot for the shortest time;
- an extensive programmed maintenance campaign which would ensure the continued effectiveness of all pollution control equipment, such as scrubbers, hooding and ducting systems; and
- a well-trained source testing or monitoring group to be maintained to measure the emissions from all sources to ensure that the air pollution control equipment is operating effectively at all times.

The Authority understands that regular inspection of the smelter operation would be undertaken under the provisions of the Clean Air Act to ensure that the control equipment is used efficiently and maintained in good working order and that the recommended emission control limits are being complied with.

7.2.2 GROUNDWATER

7.2.2.1 Introduction

The groundwater resources of the Kemerton area are described in Section 4.2. For the purpose of this Section it is important to recall that they consist of an unconfined surficial aquifer and a number of underlying aquifers which are more or less discrete, being largely confined between layers of impervious sediments. There is, however, likely to be some degree of connection between the surficial aquifer and the uppermost of the semi-confined aquifers in the Leederville Formation. The wetlands of the area are essentially surface expressions of the surficial water table.

The functioning and dynamics of the groundwater system in the area are of significance to the proposed aluminium smelter for the following reasons:

- for operational reasons a minimum separation must be maintained between the potlines and anode bake furnace, and the underlying groundwaters (see Section 7.1.1.1);
- the development has the potential to cause groundwater impact either by inducing changes to the water table or by introducing pollutants to one or more groundwater aquifers. The fate of the pollutants will be determined by the groundwater flows and ability of the soil to bind the pollutants; and
- the development proposes to extract a substantial quantity of groundwater for process cooling purposes.

The water table depth and groundwater characteristics in the Kemerton area would play a major role in determining the suitability of the site for development and would be a determining factor for disposal options for process waters.

Section 7.2.1.1 and 7.3.2.2 are also relevant to a consideration of groundwater.

7.2.2.2 Water table Impacts

The surficial water table is dependent upon dynamic interactions between water inputs, in the form of rainfall and in some areas irrigation, and water losses through surface evaporation, surface and subsurface drainage, transpirational uptake by vegetation and groundwater extraction via bores.

The behaviour of the water table in response to changes to one or more of these factors will be dependent upon the characteristics of the aquifer. The aquifers in the Kemerton area are known from regional information (Sanders, 1974; Commander, 1982; Geological Survey of WA, 1985) and experience with similar aquifers elsewhere in the Swan Coastal Plain.

While this is adequate in many respects, the extent of the interconnections between the surficial aquifer and the underlying aquifer in the Leederville Formation requires site-specific information in order to predict its effects on the response of the aquifer to increased pumping or drainage.

Major changes in the water table would have significant environmental impacts on wetlands and their associated vegetation. Wetlands in the Kemerton area, in common with those elsewhere on the Swan Coastal Plain, are surface expressions of the surficial water table. As the wetlands are typically shallow and seasonal, even small changes in the water table caused by pumping or improved drainage will cause substantial changes in the period for which the wetlands retain water. The distribution of some native vegetation species has also been shown to be influenced by changes in depth to water table caused by groundwater extraction (Heddle, 1980).

The proponent has not undertaken site-specific investigations to determine the local characteristics of the aquifers and to enable it to predict the impacts of the proposal on the water table.

There are however, several means by which the proposed smelter could affect the water table:

- the local hydrological cycle could be modified by the construction of the extensive structures and sealed aprons associated with the smelter. These structures change infiltration patterns, and site drainage proposals designed to direct runoff away from the smelter but retain runoff contaminated by fluoride concentrations greater than 1.5 milligrams per litre. These proposals may have some local effect on the surficial water table;
- the proposed extraction of some 400-1300 megalitres per year (1000-3600 cubic metres per day) from the semi-confined Leederville Formation for smelter requirements may have some impact on the surficial water table. The extent of any such impact would depend upon the degree of interconnection between the surficial and Leederville aquifers. However, it is considered that the degree of interconnection is likely to be minor and depression of the Leederville Formation aquifer as a result of pumping is unlikely to have more than minimal effects on the surficial water table; and
- the proponent could attempt to achieve adequate separation between the potroom and underlying groundwater by extracting groundwater and depressing the water table beneath the smelter. Nearby areas of native vegetation, particularly the south-eastern wetland system, may be affected by this course of action. The proponent has not indicated how it proposes to overcome the problems of insufficient separation between the smelter and the water table. Their proposals should be addressed in the EMP.

The maintenance of wetlands, the most significant natural environment represented in the Kemerton area (Section 4.2), is dependent upon maintenance of the surficial water table at, or close to, its existing range of seasonal levels. It is not possible to predict the effect of the smelter proposal on the surficial water table from the information presented in the ERMP. Predictions would only be possible when the results of the studies proposed in Recommendation 2, and the design details for the project have been determined. The Environmental Management Programme should specifically address management and monitoring strategies to ensure the maintenance of the existing surficial water table level regime.

7.2.2.3 Groundwater Contamination

The effects of contaminants, particularly fluorides, deposited in or on the soil, or discharged as liquid effluents would depend in large part upon the ability of the soil to bind the contaminant. Preliminary investigations undertaken on behalf of the Authority into the properties of soils in the vicinity of the smelter site indicate that some of these soils, notably the Gavin and Joel sands, have a very low fluoride-binding capacity. These studies are detailed further in Appendix B. The study findings conform with the results of previous studies reported in Department of Conservation and Environment (1980b), which demonstrated that these soils also have low capacity to bind phosphorus. Yeates (1981) and Barrow (1966) showed that the Bassendean Sands also have minimal capacity to retain sulphur (Section 7.2.2.1). These studies are indicative of the extremely leached nature of the sands, which contain little clay and few of the elements (such as iron, aluminium and calcium) which are normally responsible for much of the binding capacity of soils.

Should the above results be confirmed by the planned lysimeter tests, many of the soluble contaminants deposited on the soil will find their way to the groundwater and be dispersed. The ERMP (from regional information in Commander, 1982), indicated that groundwater movement on the site was from east to west. More recent investigations by the Geological Survey of WA indicate that surficial groundwater movements fan out from the site in a south-easterly to south-westerly direction, entering both the Wellesley River and the Leschenault Inlet (Figure 6). These

flow patterns indicate that groundwaters from the immediate smelter site surrounds, which are likely to receive the highest pollutant levels, will flow through both the seasonal and permanent wetlands to the west of the site. It also suggests that these waters will be diluted as the groundwater plume disperses.

The Geological Survey of WA estimates from soil transmissivity and water table gradient information that lateral groundwater movements in the surficial aquifer of approximately 50-100 metres per year are likely. At these rates of movement, contaminated groundwater would rapidly enter wetlands and the Wellesley River.

The smelter has the potential to introduce contaminants to the groundwaters of the Kemerton area through a number of mechanisms including:

- the disposal of construction wastes;
- deposition of air pollutants on the soil surface and their subsequent movement to the water table;
- disposal of liquid wastes; and
- disposal of contaminated solid wastes.

The major pollutants associated with aluminium smelters are fluorides and sulphur dioxide (SO_2) dispersed as air pollutants and as particulates and solutes in runoff from the plant and sealed apron, process cooling waters which will contain fluorides, and sewage effluent. The proponent has not stated the final composition or volume of the process cooling waters, other than to indicate that they will contain some fluoride. The disposal of wastewater is specifically addressed in Section 7.2.3 of this Report.

The disposal of contaminated solid wastes has not been finalised by the proponent, and will be the subject of further assessment. The implications of disposal of spent cathodes on groundwater are a major consideration mitigating against disposal of these wastes on site. This issue is addressed in Section 7.2.4.

7.2.2.4 Impact of Air Pollutants on Groundwater

As indicated above, and discussed in greater detail in Section 5.3 the major air pollutants emitted by aluminium smelters are fluoride (in various forms) and sulphur dioxide (SO_2). The impacts of these pollutants on groundwater derives from direct deposition on the ground, from pollutants washed or leached from vegetation, or deposited by litterfall on the soil surface and subsequently transported in solution to the groundwater following rainfall. These issues were not addressed in the ERMP, which considered only the concentration of fluorides in the air.

The concentration of these pollutants in soil solutions will depend upon the quantity deposited on the vegetation and soil surface (which will increase with the time since the last rainfall and generally decrease with distance from the source), the solubility of the pollutant and the quantity of rainfall in which it is dissolved.

Fluoride

Murray (in press) has measured the deposition rate of fluorides on the ground in eucalypt-dominated forest, 500 m from the Kurri Kurri smelter in New South Wales, at 2.7 grams of fluoride per square metre per year (Figure 25). Modelling undertaken by the Authority for the Kemerton site suggests that the direct deposition of fluoride 500 metres from the Kemerton smelter, which corresponds approximately to the edge of the sealed apron, would be similar to that recorded by Murray. Given an average annual rainfall of 875 mm (based on the average annual rainfall at Bunbury) this rate of deposition gives a worst-case groundwater fluoride concentration of 3.08 milligrams of fluoride per litre.

This calculation assumes that all fluoride is soluble and that none is bound in the soil profile. In practice however, only about 50 percent of total fluoride emissions are water soluble and even on the Gavin sands, a considerable proportion of the soluble fluoride would be likely to be bound in the soil profile and would not find its way to the groundwater. From knowledge of the leaching of phosphate, which behaves similarly to fluoride, only some 30 percent of the fluoride may be leached to the water table (Ho, 1985). Using these more realistic assumptions, the most likely groundwater fluoride concentration adjacent to the smelter would be 0.45 milligrams per litre in the Gavin sands. In other soil types a higher proportion of soluble fluorides would be found and less fluoride would reach the groundwater.

Fluoride deposition rates to the ground would decrease with increasing distance from the source, and as such, groundwater fluoride concentration would decrease with distance from the smelter. Conversely, after periods of accumulation over summer drought, dissolution by rainfall would result in flushes of considerably higher fluoride concentrations moving through the soil. These peak concentrations will be diluted on mixing with groundwater.

An issue of concern is the potential impact of fluoride-contaminated polluted groundwater on the wetland ecosystems, including those of the Wellesley River and Leschenault Inlet.

The fluoride input to wetlands is from shallow groundwater and direct fluoride deposition on

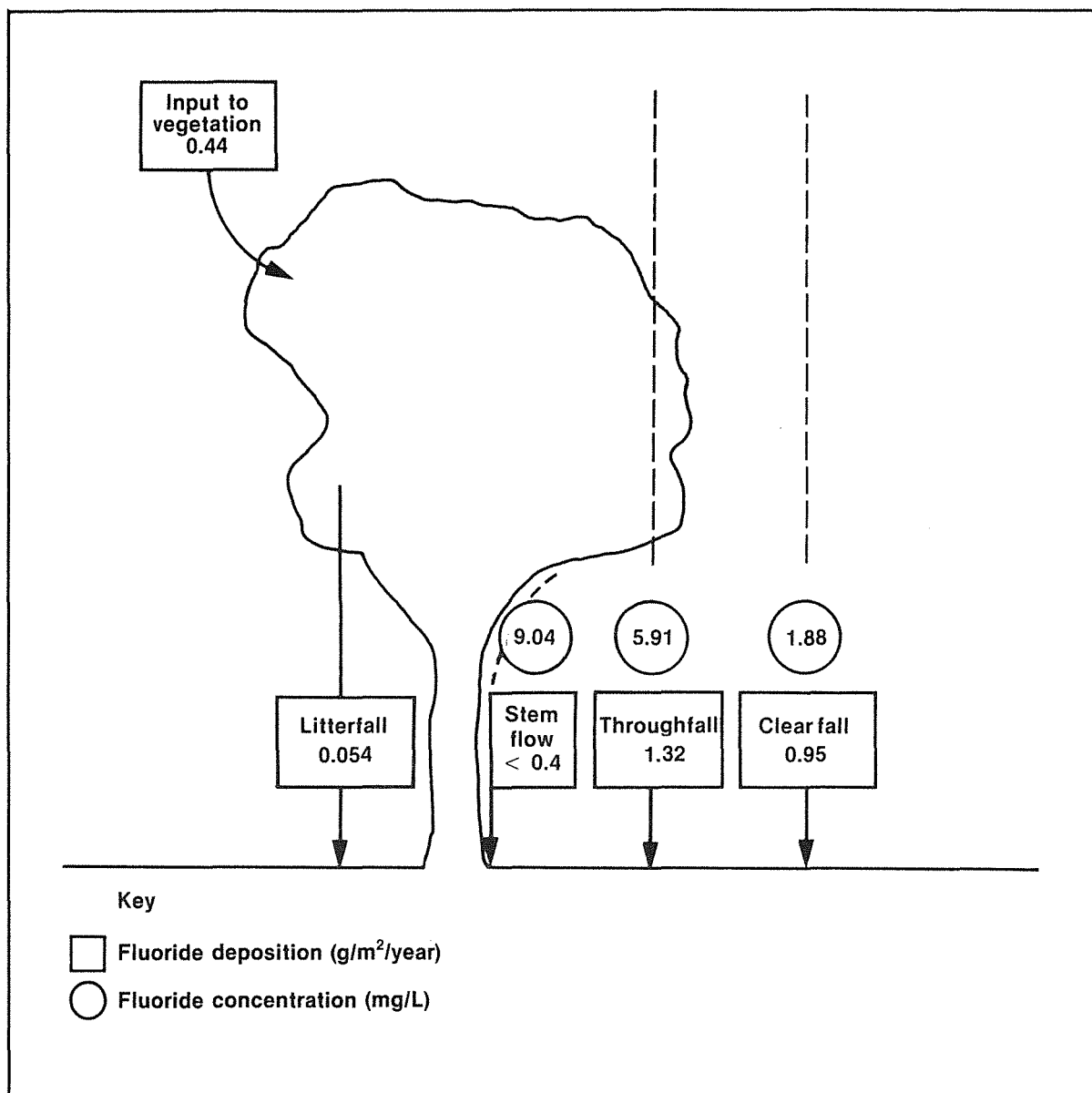


Figure 25 — Predicted Fluoride to the Ground in Eucalyptus Woodland, Deposition Rate of 0.5km from the Smelter. Source: Murray (in prep)

the surface of the waterbodies. Although the ERMP mentioned both sources of input to wetlands, it only considered the contribution of airborne emissions in detail.

Assuming the above conservative estimate of fluoride concentration in groundwater of 0.45 milligrams per litre and the additional 0.5 milligrams per litre predicted in the ERMP for soluble fluoride deposition on the surface, the total fluoride concentration in those wetlands likely to receive the highest concentration of airborne fluoride, would still remain below the level of 1.5 milligrams per litre which is considered to be the level at which harmful effects occur (US EPA, 1980).

This estimate is conservative, both in terms of the likely quantities of fluoride added to the wetlands, and retention of soluble fluoride in the wetlands. It assumes that there is no interchange of the water between the wetlands and the groundwater with which they are in continuity and that, despite the high organic content of the water and freshwater benthos, all fluoride would remain in a biologically active form in solution.

It is considered unlikely that all fluoride in wetlands would remain in a soluble, biologically active form for long, and because of this, fluoride concentrations in solution may not be substantially elevated as a result of the wetlands drying. This should, however, be verified in monitoring programmes.

It is suggested that the proponent should monitor seasonal and long-term trends in soluble and total fluoride concentrations in the wetland ecosystems before and after smelter start-up and determine rates of accumulation and the effects, if any, of the fluoride.

Contamination of Wellesley River by fluoride-contaminated groundwater is expected to be relatively low because of the perennial flows ensured by irrigation and drainage of agricultural lands in the Wellesley catchments. Fluoride concentrations in the Wellesley River are therefore expected to be lower than those in lentic* (non-flowing) wetlands in the Kemerton area.

Although the proponent has not finalised its plans for disposal of fluoride-containing process waters and site runoff, the suggestion in the ERMP that effluents with a low fluoride concentration could be released to drainage lines, would add further to the fluoride load of the Wellesley River (see Section 7.3.2.2 for further discussion of this aspect). The Wellesley River should be included in a programme of ongoing monitoring of wetlands in the Kemerton area.

Little specific information on groundwater input to the Leschenault Inlet, the other potential route of fluoride contamination, is available. Hydrological studies of the Peel-Harvey estuarine system (Department of Conservation and Environment, 1980c) have shown that groundwater contributes less than 1% of the freshwater entering to the system. The hypersalinity of the northern Leschenault Inlet in summer suggests that the same is likely to be true for this estuary, and therefore groundwater is unlikely to be a major source of fluoride.

Calculations by the proponent, in the Supplement, also suggest that fluoride input to the Inlet would be small, and not likely to be a problem.

Despite the belief that fluoride from the smelter is not likely to cause adverse impacts on Leschenault Inlet, a programme of monitoring should be established in the EMP to determine baseline fluoride concentrations in the Inlet (including specifically the edible species of fish and crustaceans) against which periodic low-key monitoring following start-up can be compared to determine whether these conclusions are valid.

Sulphur Dioxide

The impacts associated with the sulphur dioxide (SO₂) produced by the smelter are discussed only briefly in the ERMP, but are addressed in more detail in the Supplement. The proponent estimates that approximately 5380 tonnes of SO₂ will be emitted per year, making the smelter a relatively small source of SO₂ (International Aluminium Consortium, p.10).

Dispersion modelling of SO₂ emissions from the smelter stacks for the Authority is addressed in Section 5.3 of this Report, and the impact of SO₂ emissions in Section 7.2.1.17. Sulphur dioxide emissions originate mainly from the stacks, at elevated temperatures, rather than from roof vents as is primarily the case with fluoride. Also SO₂ is not as reactive as fluoride, therefore dispersion and deposition patterns are not as closely concentrated around the point of emission.

Calculations of deposition rates derived from the Authority's modelling of SO₂ emissions, suggests an annual deposition rate of approximately 7.6 kg of SO₂ per hectare, equivalent to the addition of approximately 3.8 kg of sulphur per hectare each year (Department of Conservation and Environment, 1985).

These additions of sulphur derived from the smelter must be seen in the context of an annual input of sulphur of approximately 5 kg/ha/yr from salt-laden sea air and precipitation. Agricultural soils in the area receive a further annual application of up to 20 or 30 kg sulphur per hectare to overcome an inherent sulphur deficiency (Department of Agriculture Farm Notes 37/84). Experience with agricultural use of the soils in the area (Yeates, 1981) has shown that they have very little capacity to retain sulphur. Unlike phosphate, sulphur does not appear to build up a reserve in the soil, even after repeated addition over a number of years.

Concerns have been expressed that sulphur deposition from SO₂ emissions could affect soil pH*, particularly in view of the very poor pH buffering* capacity of the Bassendean Sands.

Research into the long-term effects of sulphur applications on the pH of the agricultural soils in the region is presently being undertaken, however, it appears unlikely that the small incremental input of sulphur from the smelter is a cause for concern.

From the above it appears likely that any sulphur not taken up by plants may be leached into the groundwater. Given the natural input of sulphur to the wetlands from sea air, as discussed above, and the high capacity of the wetland sediments to store sulphur, it is not anticipated that sulphur load* from the smelter will detrimentally affect wetland systems.

7.2.2.5 Groundwater Resources

The Kemerton area is a proclaimed groundwater area, and as such all bores must be licensed by the Public Works Department.

The surficial groundwater in the region is a major source of freshwater, with salinities usually less than 500 milligrams per litre. This resource is extensively used for irrigation purposes via shallow, low capacity bores.

In the vicinity of Bunbury, the deeper Leederville Formation contains freshwater, and this is used to supply Bunbury with water for domestic and industrial supplies and for irrigation. However, a regional drilling programme, undertaken by the Geological Survey of WA in the Kemerton area, indicates that in this area salinities are higher, typically in the range of 1000-1200 mg/L.

Supplementary information provided by the proponent indicates that the water requirement of 3.6 million litres per day stated in the ERMP is an upper estimate as the Tomago smelter in N.S.W. uses approximately one third of this amount (International Aluminium Consortium, p.31). In comparison, the City of Bunbury extracts approximately 20 million litres per day, and irrigated farms in the region are licensed to extract between 2 and 10 million litres per day.

Groundwater in the Kemerton area is not extensively used at present, and no major use, other than that proposed for the aluminium smelter is anticipated. The Public Works Department (1985) has indicated that it does not anticipate problems associated with the use of the water resources in the Leederville Formation by the smelter. The buffer area around the proposed smelter will further reduce the possibility of future competition for the same water resources.

7.2.3 WASTEWATER DISPOSAL

7.2.3.1 Introduction

The aluminium smelter will generate three streams of liquid waste: runoff from rainfall on the buildings and surrounding sealed apron; process cooling water; and domestic wastes.

The proponent has not as yet developed final treatment and disposal proposals for any of the liquid waste streams and has indicated in the Supplement (p.33) that proposals will be presented in the EMP, when information on environmental constraints and smelter characteristics are available.

The proponent has indicated that the treatment and disposal techniques adopted would make maximum reuse of collected and treated wastewater, and would not compromise the interests of other users of surface or groundwater resources (International Aluminium Consortium, p.32). The Authority agrees with these principles.

7.2.3.2 Sewage

The ERMP indicated that a package sewage treatment plant would be established on site and that treated effluent would be disposed of by spray irrigation following an appropriate maturation period. The Authority notes the proposed establishment of a package treatment plant and has recommended that it be established as early as possible during the construction phase (Recommendation 5). Given the poor phosphorus binding capacity of the Gavin and Joel sands and the shallow water table there is a possibility that phosphorus in the effluent could enter local wetland systems where it may lead to problems of excessive nutrient enrichment.

The Authority notes that the proponent indicated in the Supplement that there was insufficient information currently available on which to base a final water management plan, and that treatment and disposal of all waste-water streams would be addressed in the EMP (International Aluminium Consortium, p.33). Nonetheless it draws the proponent's attention to the fact that it does not favour the disposal of treatment effluent by spray irrigation, unless it can be demonstrated in the EMP that phosphorus in the effluent will not enter and detrimentally affect the wetland systems in the surrounding areas.

7.2.3.3 Site Runoff and Process Water Streams

Site runoff and process water streams would both contain fluoride and present similar disposal problems.

Site runoff is likely to contain fluorides, suspended solids and oils. These contaminants are derived largely from particulars that have settled on the structures and sealed apron, and from spillages of lubricants and materials from some process sources. The concentration of contaminants in runoff will vary with the length of time since the last period of rainfall and the quantity of rainfall in which the contaminants are diluted. In this context rainfall following a period of summer drought will contain the highest pollutant concentrations. Fluoride in solution and as suspended solids is likely to be the major contaminant associated with site runoff. Estimates of a maximum fluoride concentration of 10 mg/L in site runoff are given in the ERMP but no arguments in support of this statement are made (Helleman, p.4-11).

The atmospheric dispersion model for fluoride, used by the Authority (Department of Conservation and Environment Bulletin No. 203), predicts an annual fluoride deposition rate of 0.73 gF/m² on the sealed apron some 500 metres from the source. Assuming an extreme case of 8 months uninterrupted accumulation of fluoride, total mobilisation of fluoride by 10 mm rainfall would yield a fluoride concentration of 49 mg/L as a reasonable worst-case situation. A more normal summer situation of 4 months' accumulation of contaminants would produce a fluoride concentration of approximately 24 mg/L following 10 mm of rainfall.

The characteristics and quantities of the process wastewater streams produced by the plant are not addressed in detail in the ERMP. It is stated, however, that the wastewater would contain fluoride, but that it would not be produced in large quantities or as highly contaminated flows. Supplementary information released in response to public comments did not enlarge upon this limited information.

More information on these aspects is unlikely to be available until the proponent has undertaken detailed design work.

7.2.3.4 Site Runoff and Process Water Disposal Options

The ERMP proposed that site runoff with a fluoride concentration exceeding 1.5 milligrams per litre, and all process wastewater would be directed to a sedimentation and evaporation pond. It further proposed that site runoff with fluoride concentrations of less than 1.5 milligrams per

litre would be directed off-site without further treatment. However, it is clear from the subsequent Supplement that the proponent has not yet finalised its disposal plans for site runoff with low levels of fluoride contamination.

Disposal options for this category of liquid waste should be determined until the proponent has baseline information on the groundwater system in the Kemerton area, and on the flow rates and biota of the Wellesley River.

The final mode of treatment and disposal of process water waste and site runoff with high levels of contamination has similarly not yet been determined. The proponent has proposed that these issues be addressed in detail in the Environmental Management Programme. It is, however, pertinent to briefly address the three disposal options mentioned in the ERMP. They are as follows:

Spray Irrigation

This is the disposal option favoured by the proponent. It would be dependent upon the fluoride-binding ability of the soils over which wastewater would be sprayed.

In the absence of this binding capacity, disposal of wastewater by irrigation would result in the addition of soluble fluorides to the water table and their movement in groundwater streams and wetlands. Most soils show a strong capacity to bind fluoride to aluminium, iron, calcium, clay, organic matter and other soil components. Preliminary investigation of the Kemerton area (discussed in Appendix B) suggests, however, that at least some of the soil types present, notably the Gavin and Joel sands of the Bassendean System, may have a very low fluoride binding capacity. A range of options such as the use of lime, or red mud from alumina refining, may be available to overcome these potential problems, but these have not been addressed in the ERMP. The issue of fluoride contamination of groundwater was addressed further in Section 7.2.2.

Deep Well Injection

This disposal option would involve the injection of liquid wastes down a bore into a deep saline aquifer, possibly the Cockleshell Gully formation. Advice from the Geological Survey of WA (1985) suggests that it is possible that only one bore would be needed to cater for the quantities of wastes produced. However, depending on the mineral content of the aquifer and that of the wastewater, precipitation of some mineral elements may result from the interaction of the two solutions, and could seal the pore spaces, greatly reducing the permeability of the rocks surrounding the bore. This process, which could occur quite quickly, would necessitate either the utilisation of a new level of the aquifer, or the repeated drilling of new bores.

In the absence of the detailed information on the composition of waste-water, the potential implications of liquid waste disposed by this means on future options for the use of this groundwater resource remain undefined.

Ocean Discharge

This option would necessitate the construction of a pipeline from the site to an ocean outfall. Information presented in Department of Conservation and Environment, (1983), indicates that, opposite the Leschenault Peninsula, the sea floor shelves gently reaching a depth of only 15-18 metres some 6 km off shore. Furthermore, current speeds are only 15-18 metres some 6 km off shore. Furthermore, current speeds are generally low and tidal range is small, factors which would inhibit the dispersal and mixing of an effluent plume. It should be recognised however that marine environments have a relatively high background level of fluoride and marine organisms generally do not show adverse impacts of fluoride below concentrations of 5 ppm (Appendix I).

In respect of this last option it is noted that:

- the northern end of the Leschenault Inlet lies in the path of the most direct line between the smelter site and the ocean;
- the coastal environment comprises a fragile topography of mobile and fixed dunes;
- the coastal areas and nearshore waters are an important recreational resource; and
- the marine waters in the vicinity of Bunbury support a significant professional and amateur fishery.

Information on the nature of the process wastewaters to be generated by the proposed smelter, and the methods of disposal of this waste are significant elements of this proposal for which the proponent has provided insufficient information to enable an assessment of likely impacts. The proponent has indicated that it intends to address wastewater issues in the EMP (Appendix K).

The Authority will need to be convinced of the adequacy of proposals for wastewater management and that the proposals must be based upon and supported by detailed information on the characteristics of the wastewater's composition and flows and of the characteristics of the receiving environment.

RECOMMENDATION 10:

The EPA recommends that the proponent should demonstrate in the Environmental Management Programme (EMP) the environmental acceptability of the proposed methods of liquid waste disposal.

7.2.4 SOLID AND NON—AQUEOUS LIQUID DISPOSAL

As outlined in the ERMP, and Chapter 5 of this Assessment Report, between 13000 tonnes and 16000 tonnes of solid waste would be generated each year from the proposed smelter (Table 7).

This would consist of the following:

- between 6550 tonnes and 9650 tonnes per year would be contaminated or “hazardous” spent cathodes, the disposal of which is not discussed in the ERMP, but which would be addressed in the EMP;
- 2900 tonnes per year which is stated by the proponent to be suitable for disposal by municipal landfill, although no landfill sites are identified in the ERMP;
- 3310 tonnes per year of solid waste, the disposal of which has not been determined by or discussed in the ERMP.

The ERMP also does not discuss the fact that other wastes would be generated. The Tomago EIS states that additional non-aqueous liquid waste would be generated which is to be disposed of in a manner similar to the solid waste. This would include:

- 100000 litres per year of waste oil; and
- 75 tonnes per year of soluble oil (Croft and Assoc., 1980).

7.2.4.1 Non-contaminated Wastes

While no clear figure is given for the quantity of non-contaminated waste generated, the ERMP states that at least 2900 tonnes of solid waste could be disposed of at a municipal landfill site per year. The ERMP also states that the smelter would generate at least an additional 3310 tonnes of solid waste per year, and disposal of which has yet to be decided. Up to 6210 tonnes of solid waste could be disposed of off-site, perhaps to a municipal landfill.

Two questions need to be examined in the EMP, these are:

- how much of the potential 6210 tonnes/annum should be classified as “hazardous” or has the potential to pollute or contaminate groundwater and hence is not suitable for disposal as landfill? For the Tomago smelter, much of this solid waste was classified as contaminated (Croft and Assoc., 1980); and
- given that a certain quantity of solid waste would be uncontaminated and non-hazardous, do local municipal landfill sites have the capacity to accommodate this quantity of solid waste over the next thirty years and is this a desirable disposal option?

7.2.4.2 Contaminated (“Hazardous”) Wastes

This waste, called spent pot-lining, originates from and is a by-product of the aluminium reduction process. The pots are lined with refractory material, usually either silica brick or alumina, which becomes contaminated and requires periodic replacement (Chapter 5). In addition, electric current is passed through and consumes the anode. This is replaced periodically and contaminates and destroys the integrity of the cathode which is submerged in the molten bath (Figure 26). Hence every three to five years, the cathode needs to be replaced in the pot although it is likely that some cathode failure would occur before this designated time frame. The potential quantity of hazardous contaminated solid waste generated by an equivalent smelter to the one proposed and its sources within the pot are shown in Table 10.

The quantity and quality of total wastes to be generated and their elemental composition are shown in Table 11.

This solid waste has a potential to create environmental problems if the chosen disposal method or location is inappropriate.

Interim Period (1985-1992)

The proponent has claimed that “the proposed aluminium plant will not generate spent cathode waste until approximately 1992” (Helleman, p.4-11). However, the Tomago EIS states that while “cathodes would generally be expected to last four years, problems associated with start-up and relatively inexperienced operators could well lead to some waste cathode material (well) before four years” (Croft and Assoc., p.136).

Furthermore, a quantity of waste (other than cathode linings) would be produced during this interim period which is not suitable for normal municipal landfill. This would be generated as soon as start-up commences and would require disposal. This includes plant sweepings (800 tonnes/yr), rodding shop spent anode wastes (1100 tonnes/yr), bake oven bag filter dust (500 tonnes/yr), and failed anodes (300 tonnes/yr). In addition, a certain quantity of spent pot-lining waste would be generated from the start-up period to 1992.

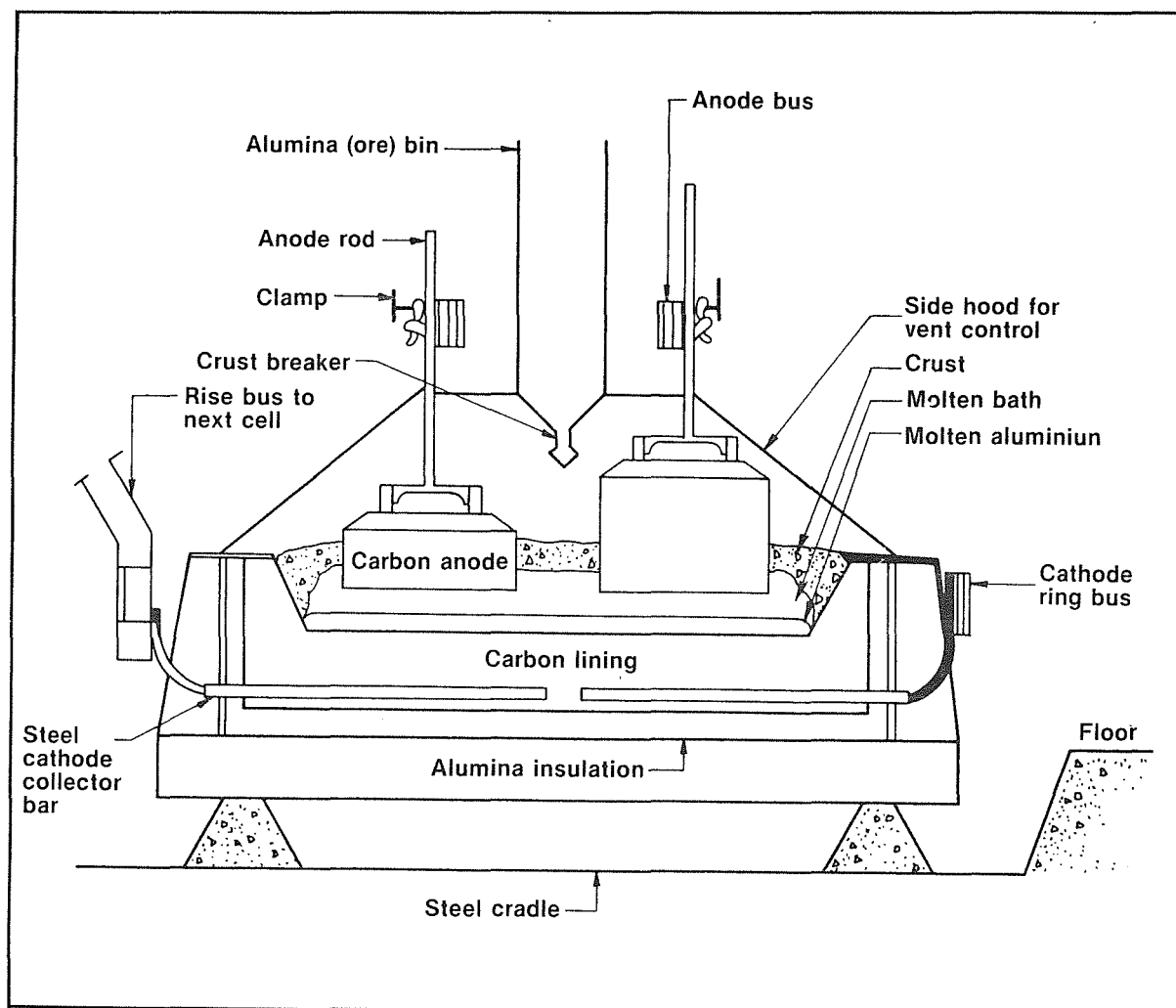


Figure 26 — Typical Cross Section CWPB Cell showing Anode and Cathode.

Source ERMP

Table 10 Quantity and Contaminants of "Hazardous" Waste produced from a 200 000 tonne/annum Smelter

	Quantity (tonnes per year)	Fluoride (percent)	Quantity of fluoride (tonnes per year)	kg F/tAl	Cyanide in parts/million (ppm)
Bricks	5 400	8	450	2.25	
Carbon	4 600	14	650	3.25	
TOTAL	10 000	N/A	1 100	5.50	900-1 500 ppm

N/A Not applicable

Source: UNEP, (1981)

Table 11 Quantity and Composition of Pot-Lining to be treated

	Plant A*	Plant B*	ELKEM*	ALCOA**	ALCAN*	Reynolds**	USA*	Proposed Kemerton Smelter ERMP***
Impregnated refractories kg/tAl	27	N/A	not included	—	not included	—	—	30
Impregnated carbon kg/tAl	23	N/A	40	—	32	—	—	30
Total quantity of impregnated kg/tAl	50	40-60	40	—	32	—	—	60
F% in the total	11	12-13	16-18	18.2	14	17.6	14 ± 4	N/A
kg F/tAl	5.5	5-8	6-7	—	5	—	—	N/A
C%	—	34	35-40	28.6	43	42.7	48 ± 10	45-60
Na%	—	17	12-16	13.9	13	20.0	14 ± 2	15-25
Al%	—	11	12-20	14.2	10	4.7	13	15-20
CN%	—	0.15 (1500ppm)	—	0.09 (900ppm)	—	0.135 (1350ppm)	—	Approx. 400 ppm

SOURCE: A* UNEP

B** Blayden & Epstein

C*** ERMP

N/A Not Available

Long-term Treatment and Disposal

The proponent has stated in the ERMP that for the long term "the means of treatment and disposal of spent cathodes, the most significant solid waste generated by plant operations, has yet to be finalised" (Helleman, Section 4.6.2), and that "the proponent intends to investigate alternative disposal strategies and to agree on an acceptable mode of treatment with the Government. This matter will be addressed in the EMP which will be prepared under the terms of State Agreement Act" (Helleman, Section 4.16.6).

The Authority notes that the proponent has undertaken to investigate engineered landfill for its feasibility as a long-term disposal method for the SPL. The ERMP states that:

"should engineered landfill either on or off-site be the adopted procedure, the Consortium accepts in principle the concept of a trust fund (established by them and contributed to by reference to the quantity of cathode waste disposed of in the landfill), whose purpose would be to provide funds to monitor the effectiveness of the disposal method and to fund any remedial works" (Helleman, p.6-10).

Although the Authority notes the proponent's commitment it is concerned that the long-term aspect of the problem could mean the problem may outlive the protection mechanism proposed.

A review of spent pot-lining solid waste disposal methods employed in other smelters in Australia shows that the problem faced in Western Australia is not unique (Table 12). In NSW, the Tomago Smelter has recently been given an approval to dispose of its spent pot-lining waste by engineered landfill, although this may only be an interim measure. However, in most of the other smelters in Australia, as in the bulk of smelters around the world, the current solution to the spent pot-lining problem is on-site (or off-site) storage, in some cases, for decades.

The Authority is aware that alternatives to engineered landfill exist and that the proponent would be investigating these methods which would treat, detoxify, recycle and dispose of the wastes without detrimental effects on the environment. Many of these methods are at pilot plant stage, e.g. pyro-hydrolysis, where the carbon in the waste is burned in a high temperature furnace. Cyanides are destroyed and fluoride is collected and recycled. A pilot plant has been operating in Norway and appears to be cost-effective (Blayden & Epstein, 1984).

Table 12 Spent Pot-Lining Waste Disposal Practice in Australia

	COMALCO Bell Bay TASMANIA	ALCAN Kurri Kurri NSW	ALCOA Point Henry VICTORIA	TOMAGO P/L NSW	Q.A.L. Boyne Island QUEENSLAND
Current DISPOSAL METHOD	Spent cathode stockpiled in open on natural clay pad-leachate treated	Spent cathode stockpiled in open on natural clay pad-leachate retained in bund wall	Spent cathode stockpiled in open on natural clay	Secure landfill approved in May 1985	Spent cathode stockpiled under cover
Annual production (tonnes per year)	N/A	N/A	N/A	10 000 (at full production)	10 000 (at full production)
Quarterly stored (tonnes)	120 000	N/A	N/A	No storage	Small quantity
Future treatment	N/A	Secure landfill	Secure landfill in clay cells	Treatment option	Treatment option

Source: State Pollution Control Commission

N/A — Not Available

7.2.4.3 Assessment of Solid Waste Disposal

In summary, the assessment of the solid waste disposal from the proposed smelter is as follows:

For non-contaminated waste

- disposal of non-contaminated waste may be a problem in the region because of a lack of available municipal landfill sites;
- the proponent needs to identify in the EMP the exact quantity and quality of waste that would be disposed off-site in municipal landfill;
- the proponent needs to ensure, to the satisfaction of the Authority, that this solid waste can be accommodated at existing or proposed municipal landfill sites available in the region without compromising Shire or other users of these facilities;
- the Authority would prefer that all combustible material be incinerated on site in a manner and with safeguards acceptable to the Authority; and
- the disposal of the waste oils and soluble oils needs to be discussed by the proponent and this information provided in the EMP.

For Contaminated and Spent Pot-lining Waste

- the proponent has not provided exact details of quantity and quality of waste produced both in the interim and long-term period;
- these wastes have the potential to contaminate groundwater due to their toxic nature;
- the proponent needs to provide, in the EMP, a solid waste disposal management plan for the interim period (1985-1992);
- this solid waste disposal management plan especially needs to address the on-site storage of SPL waste during the interim 1985-1992 period. The on-site storage should be hard sealed/concreted, roofed, kerbed and guttered so as to prevent ingress of rain-water or wash-down water;
- the long-term engineering landfill method of disposal is inappropriate for the Kemerton site due to the soil characteristics and high groundwater regime of the region (Section 4.2); and
- the proponent has made a commitment to investigate long-term solid waste treatment methods. The results of these should be provided to the Authority for assessment.

The Authority notes that while the proponent has not provided adequate information on solid waste disposal, the proponent has undertaken a number of commitments on this matter (Appendix K).

RECOMMENDATION 11:

The EPA recommends that the proponent should address in the EMP its proposals for the disposal of non-contaminated wastes.

RECOMMENDATION 12:

The EPA recommends that the proponent should provide details to the EPA on the interim storage and disposal of all solid waste. Any methods of storage should be designed so as to prevent the formation and escape of leachate.

RECOMMENDATION 13:

The EPA recommends that proposals for long-term treatment, storage or disposal of contaminated waste should be provided by the proponent to the EPA for assessment within two years of the commencement of operation.

7.2.5 NOISE

The operation of an aluminium smelter would generate noise. The ERMP states that "under all atmospheric conditions, the great majority of the potential (noise) impact zone (i.e. within the 35 dB(A) contour) falls within the area to be managed by the Government" (Helleman, p.7-25). The proponent then concludes that the noise impact due to the operation of an aluminium smelter in the Kemerton area "will not be significant".

The Authority believes that this claim has not been substantiated, on the basis of the information presented in the ERMP.

Sources of noise from aluminium smelter, would include:

- mechanical equipment including fans, pumps, etc.;
- transportation (internal and external);
- material handling; and
- smelter intercom system.

The noise source data, as presented in the ERMP, are shown in Table 13.

Table 13 shows that the proposed aluminium plant would be emitting a sound power level* of 120 dB(A) over the frequency range (in octave levels) of 63 Hertz (Hz) to 4000 Hz. The ERMP indicates that this quantity of noise is expected, through computer modelling, to be attenuated* to 40 dB(A) within approximately two kilometres from the centre of the potline, even during the 'worst case', i.e. summer 'inversion' condition.

Table 13 Assumed Noise Spectrum Data

Source	Frequency in Hz (octave levels)	63	125	250	500	1000	2000	4000	Total Noise Level
Proposed Aluminium Plant Noise Level dB(A)		106	114	114	112	109	108	106	120

While computer modelling may indicate potential noise contours, it is also necessary to calibrate the model by undertaking noise attenuation tests. This should form part of the EMP.

Also as seen in Figure 27, there are a substantial number of dwellings within four kilometres from the smelter site. A number of methods by which noise can be reduced or controlled during the construction phase have been previously mentioned (see Section 7.1.2.3).

Noise control methods also exist for the operational phase and have been used in other smelters in Australia. These include the following:

- lagging of fans, pumps and pipes;
- rubber lining of material handling equipment at the contact point;
- transport equipment with integrated silencers; and
- a plant intercom system to designed so as to avoid nuisance, especially at night-time.

Besides those mentioned above, there are other methods by which the smelter in-house noise can be reduced. The Authority is of the opinion that it is the responsibility of the proponent to undertake its own investigation on how this in-house noise would be reduced or controlled during the operation phase of the smelter. The proponent needs to present this information to the Authority in the EMP, and demonstrate that the noise generated from the smelter would not detrimentally affect the acoustical amenity of the Kemerton area.

The proponent will need to comply with the prevailing noise control legislation and regulations.

RECOMMENDATION 14:

The EPA recommends that the proponent should be required to comply with prevailing noise control legislation and regulations.

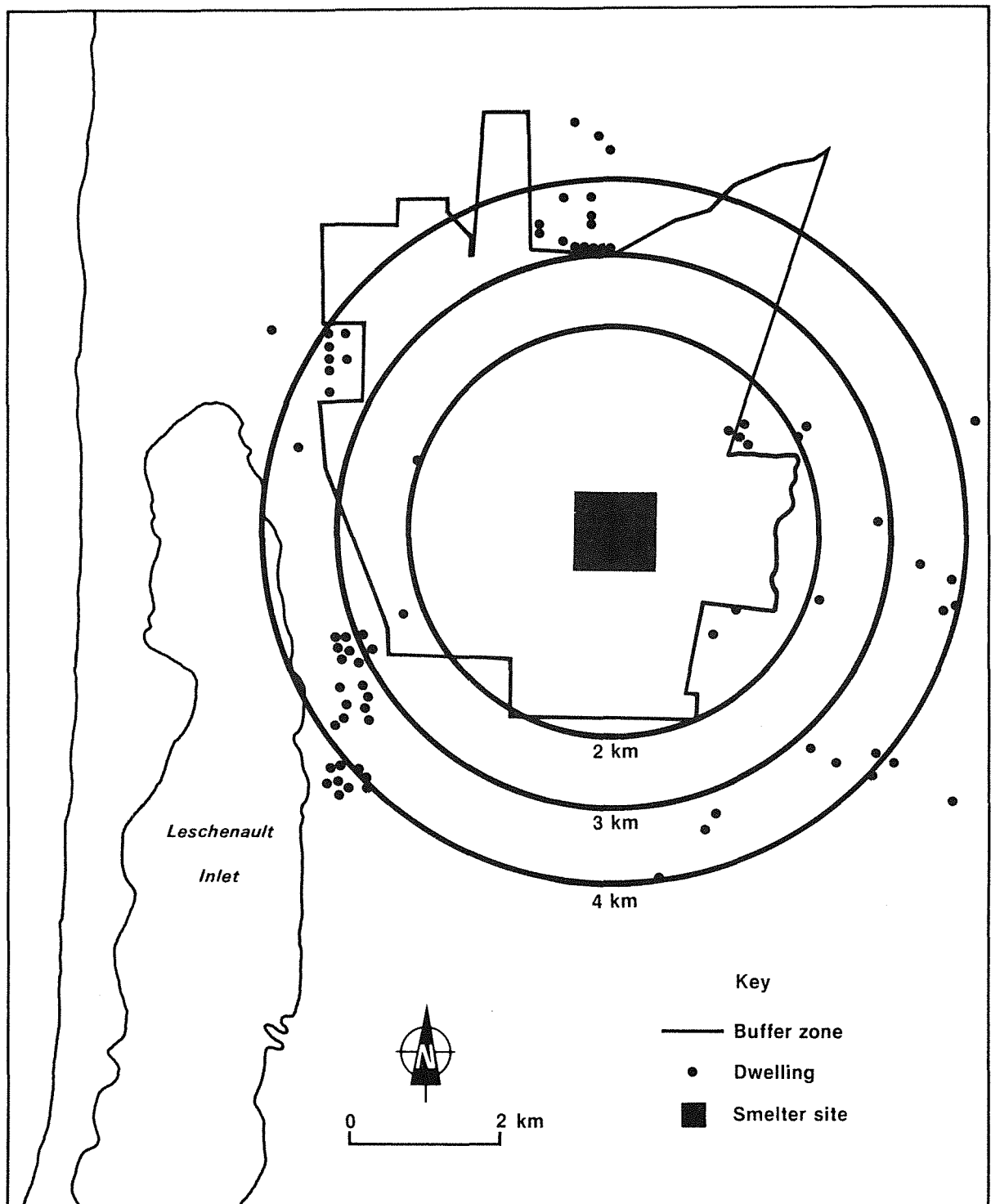


Figure 27 — Distribution of Dwellings in the Kemerton Region.

8. SOCIAL IMPACT ASSESSMENT

The ERMP contained only a very brief assessment of the likely social impacts of the smelter. In the context of concerns expressed by the Authority and the Shire of Harvey about the lack of consideration given to social impacts, and because some quantification of the social impacts was necessary so that mitigating measures could be planned, the WA Government commissioned a subsequent study. The report entitled "Community Needs Study — A Socio-Economic and Social Impact Assessment of the Proposed Kemerton Aluminium Smelter" (Dames and Moore, 1985b) was co-ordinated by the Department of Resources Development. The Community Needs Study provides an analysis of the likely social impacts of the smelter development, proposes measures for ameliorating and mitigating the impacts and suggests methods of funding these initiatives.

At this stage the Community Needs Study Report (the Study) is a consultant's report to Government: the recommendations have not been formally accepted or endorsed by Government but will form the basis for discussions. The release of the Study to the public on 18 June 1985 to give people the opportunity to provide input, did not allow the Authority to take account of public comments in this assessment.

The Authority has not summarised the contents of the Study as it has assumed that the report will be widely read. The summary and recommendations for mitigating impacts are, however, presented in Appendix J of this Assessment Report. The Authority will make only brief comments on the social impacts of the smelter in this section of the report.

8.1 NATURE OF THE SOCIAL IMPACTS

The Study identifies and describes a wide range of potential impacts and suggests methods for preventing and managing them so that they will not be disruptive to the communities in the area. Potential impacts on populations, employment, housing, education facilities, health services, community organisations, support services, social infrastructure, transport (especially roads) and community attitudes are all addressed in the Study.

The impacts are all manageable if the proponent and agencies with responsibilities in planning, welfare, social services and co-ordination work together with the local authorities. However, to ensure that adequate monitoring of demands on social infrastructure facilities takes place it would be necessary for appropriate officers to be located in the area, consequently the Authority makes the following recommendation:

RECOMMENDATION 15:

The EPA recommends that effective management of social needs would require that officers with co-ordinating responsibilities be located in the region.

The Authority concurs with the proposals for support systems already proposed, namely the proponent's Community Relations Officer (Helleman, p.8-5) and the provision of a Community Liaison Officer for the Shire of Harvey (Dames and Moore, 1985b, pp.5 and 98). Both these people would need to be available in the area at the commencement of the construction phase.

8.2 NATURE OF THE COMMUNITIES

The communities to be impacted fall into three main categories:

- people resident in the immediate vicinity of the Kemerton area;
- people resident in the Bunbury region; and
- people who will move into the region during either the construction or operation phases.

8.2.1 IMPACTS ON PEOPLE RESIDENT IN THE IMMEDIATE VICINITY

The people living close to the proposed smelter site would be those most likely to be inconvenienced to some extent by the development. Specific impacts of concern to the Authority would include noise, traffic and dust.

8.2.1.1 Noise

The construction of a large industrial plant generates noise, particularly from on-site earth-moving equipment and on-site and off-site truck movements.

During its operation, the smelter would generate noise from a number of sources such as the emission control machinery and also the plant intercom system.

Whether the noise would constitute a nuisance to nearby residents would depend upon how well noise sources are managed. The proponent would have to comply with the Noise Abatement Act during all stages of construction and operation. Recommendation 14 addresses this.

8.2.1.2 Traffic

There are two main ways in which traffic can have a social impact on communities, namely via noise and perceived changes to the safety of roads.

Noise from traffic is generated from a number of sources, the most common being:

- roar of traffic;
- noise of empty trucks in particular;
- vehicle body noise (e.g. rattles);
- tailgate noise;
- engine noise;
- air-brake noise;
- squealing brakes;
- gearbox noise and gear change noise; and
- exhaust noise.

Methods are available to reduce markedly noise from these sources e.g. quiet exhausts, engine noise shielding. In addition particularly quiet vehicles are already available.

Noise aspects of traffic are covered by the Noise Abatement Act and the Road Traffic Act.

Road Safety from increased vehicular movement can also cause concern. Safety aspects have already been given some consideration by the Shire of Harvey, particularly in the area of possible shift change times and the timing of school buses.

8.2.1.3 Dust

Dust is a problem in cleared paddocks and land during strong winds. In addition, dust would be generated on the smelter site during the construction phase from earthmoving and from transport of materials by road. During the operations stage dust would be generated mainly from trucks carrying supplies to the plant and carrying solid wastes away from the site. Dust could become a nuisance to people living close to the smelter and along access roads, if it is not adequately managed. Recommendation 4 in Section 7.1.1.3 addresses this.

8.2.2 IMPACTS ON PEOPLE RESIDENT IN THE BUNBURY REGION

The Study indicates that the region contains an established and efficiently organised set of communities which should be able to absorb the impacts of the development. However, there would be extra costs incurred by the community as a whole, in the development of extra facilities such as roads and schools. The proponent and the various government agencies should agree to an appropriate cost-sharing mechanism in order to pay for these extra costs.

8.2.3 IMPACTS ON PEOPLE MOVING INTO THE REGION

Most of the impacts on these people would be minimised if the relevant agencies take account of the increased population resulting from the development of the smelter in their forward planning.

It may be appropriate to consider the extra risks to health and safety associated with commuting to the site during both the construction and operation phases. If studies (perhaps based on other, similar decentralised major projects) indicate a need, then some form of alternative transport (e.g. car pooling or provision of buses) may be warranted and the proponent should consider this.

8.3 ABORIGINAL SITES

In the ERMP the proponent indicates that a preliminary archaeological survey of the proposed plant site did not identify any Aboriginal sites and that there is nothing to suggest the presence of sites of anthropological interest. No information has been provided in the Conceptual Land Management Plan on whether sites of archaeological or anthropological interest are present in the proposed buffer area, which will be physically disturbed during establishment of the pine plantations.

The proponent and the Department of Conservation and Land Management should liaise with the WA Museum on its legislative requirements regarding Aboriginal sites.

9. CUMULATIVE IMPACTS AND INTERACTIONS

Cumulative impacts from concurrent or sequential development of major projects within the same region result from the combined effect of, and interactions between, particular environmental impacts. The consequential land use implications of the development projects also need to be considered in assessing the likely cumulative impacts.

Assessing the cumulative environmental impacts of developments is an important part of the environmental impact assessment process.

The guidelines for the ERMP indicate that:

“the document should also consider potential cumulative impacts (including the social impacts) in the context of existing and future developments (notably the state government’s proposal for land-use in the surrounding area and the titanium dioxide plant), Bunbury 2000, and any other significant proposals or developments currently underway in the Bunbury area.” (Appendix A, p.4)

The proponent did not discuss cumulative impacts and only identified three possible concurrent projects (Helleman, Section 1.8 and Table 1.1). Table 14 lists major projects currently planned for the Bunbury/Collie area, of which the Authority is aware.

9.1 REGIONAL AND OTHER PLANNING CONSIDERATIONS

The land use framework for the near-Bunbury region is based on substantial industrial growth, but does not provide for an aluminium smelter at the Kemerton site or elsewhere. However, the proposed smelter is so large a project that it would be unreasonable to expect that it would neatly fit into the prevailing land use framework. Although this framework could be modified to provide for the proposed smelter, the scale of the proposal and consequential development it would generate have planning implications which need to be considered.

9.1.1 STRATEGIC PLANNING FRAMEWORK

Land use planning is a dynamic process and it follows that land use strategies (e.g. BRP and TPS No. 10), regardless of their scale, must be able to accommodate change. However, it is important to recognise that major industrial development at Kemerton would be a significant departure from the adopted regional land use strategy and that this change may have implications for the regional strategy including the following:

- possible constraint of long-term northwards expansion of Australind;
- difficulties in the staging and servicing of urban growth;
- prevention of alternate use of the Kemerton area;
- possible reduction of amenity in existing special rural zones adjacent to the Kemerton area; and
- possible intrusion of the development on the alignment of the Australind/Eaton regional by-pass route.

All of these issues were raised in submissions received on the ERMP.

Based on experience elsewhere, the Authority is aware that development of the smelter as proposed could lead to pressures for further industrial development in the Kemerton locality (to capitalise on services provided to the smelter site), and possibly establish a precedent for industrial development in other areas not designated for such under the BRP. The possibility of industrial development in the Leschenault Inlet environs would be of particular concern in this regard.

Although the above-mentioned issues relate specifically to the strategic planning framework, in most instances they do involve environmental considerations. Accordingly the Authority recommends as follows:

RECOMMENDATION 16:

The EPA recommends that the consequential planning implications of establishing an aluminium smelter in the Kemerton area should be identified by the Town Planning Department and duly considered and that in such consideration, environmental issues should be thoroughly addressed.

9.1.2 INDUSTRIALISATION OF BUNBURY

The level of industrial development proposed under the BRP could lead to a marked change in the physical and social character of Bunbury. However, implicit in decisions to adopt the regional strategy is recognition and acceptance of this possibility. It would therefore be difficult to sustain any suggestion that establishment of the proposed smelter and consequential developments would be undesirable in terms of Bunbury’s perceived future character.

Project Type	Location	Project Proponent	Construction Period	Construction Workforce			Start-up Date
				Average	Peak	Year of Peak	
Infrasctructure projects directly associated with smelter development (a) • 330 kV transmission line (b)	Muja/Collie Power Stations to Kemerton Site	SECWA	1986/87	Commencement 10	80	plus 15-30 per substation at Harvey and Kemerton	1987
• railway line	South-Western Line to Kemerton Site	Westrail	1986/87	N/A	N/A	N/A	
• upgrading of port facilities	Inner harbour Bunbury	Proponent Bunbury Port Authority	N/A	N/A	N/A	N/A	
Projects indirectly related to smelter (a) development • 600 MW Power Station	Collie	SECWA	1985-93	310	840	1990	N/A
• coal mine (to supply Collie Power Station)	Collie						
Concurrent but unrelated projects • Muja D Power Station	Collie	SECWA	1980-88	350	650	1985	1987/88
• upgraded ilmenite plant	Capel	Westralian Sands	1985-87	N/A	200	N/A	N/A
• Highway by-pass	Australind	MRD	N/A	N/A	N/A	N/A	N/A

a) Assumes smelter operational in 1987

b) Source: SECWA 1985

N/A Not Available

Nevertheless, it is important that the nature of industrial growth occurring and its physical and socio-economic consequences be carefully monitored as a safeguard against undesirable change or unforeseen impacts. This monitoring would, it is anticipated, occur as a normal part of the on-going strategic planning process.

Monitoring of the cumulative impact of industrial growth at Bunbury is also important in another context relating to the regional land use strategy. This strategy incorporates a buffer concept based on the classification of industrial activities according to their potential to adversely affect adjoining lands. The total load of pollutants discharged to the regional airshed is an important element of the industrial buffer/classification concept and there is a consequent requirement for continuing air quality monitoring.

RECOMMENDATION 17:

The EPA recommends that monitoring of the total airshed pollution load at Bunbury should continue.

9.1.3 CONCEPTUAL LAND MANAGEMENT PLAN

Cumulative impacts arising from the proposal to establish forest production in the Kemerton area include impacts on groundwater resources, planning aspects and recreation considerations. These are addressed in Section 9.2.1 and Appendix E respectively.

9.1.4 SYSTEM 6 STUDY

The System 6 recommendations affecting the Myalup Swamp/Mialla Lagoon wetlands and the Wellesley River have broad planning implications (Environmental Protection Authority, 1983).

The State Government has adopted the System 6 recommendations in principle, and, therefore, it is important that options relating to the recommendations should not be foreclosed. The BRP, Shire of Harvey TPS No. 10 and, in particular, the Conceptual Land Management Plan have implications in this regard.

The BRP identified both the Myalup Swamp/Mialla Lagoon wetlands and the Wellesley River as "Areas Under Consideration For Conservation and Reserves". TPS No. 10 identifies the relevant section of the Wellesley River as an area within which development will be scrutinised. The Conceptual Land Management Plan includes Mialla Lagoon (but not the Wellesley River) within a conservation priority area (Forests Department, 1985).

The Conceptual Land Management Plan could provide a means for achieving the intent of the System 6 recommendations although, in its present form, it does not. This matter is discussed further in Appendix E.

9.2 CUMULATIVE BIOPHYSICAL IMPACTS

9.2.1 GROUNDWATER RESOURCE DEMANDS

The proponent has indicated its intention to extract between 400 and 1300 ML per year of water for plant requirements from underground aquifers in the Kemerton area, most likely in the Leeder-ville Formation. These quantities would make the smelter a substantial user of water in the region (for further discussion of this issue, see Section 7.2.2.5).

The Authority understands that water resources sufficient to meet these demands are available in the groundwater aquifers. Advice from the Public Works Department indicates that these aquifers are presently not extensively used in the Kemerton area, though further south, where they contain water of higher quality, they provide the domestic and industrial water requirements of Bunbury.

The Public Works Department has advised that no other uses which could compete with the smelter for the groundwater resource are likely in the Kemerton area, in the foreseeable future. Additionally, the Public Works Department considers that the proposed buffer area surrounding the smelter site would provide sufficient clearance around the extraction points to minimise the possibility of constraints being applied on future groundwater users in surrounding areas.

Potential impacts on groundwater from the establishment of pine plantations proposed under the Conceptual Land Management Plan have not been addressed, either in the Plan or by the Authority. This is an aspect that should be investigated by the Department of Conservation and Land Management (Recommendation 25 in Chapter 11, and Appendix E).

9.2.2 COAL MINING

To achieve an annual output of 230000 tonnes of aluminium metal, the proposed smelter would require approximately 3.5×10^6 MWh of electrical energy. This would be provided from the SEC-WA interconnected electricity grid.

Until 1995, much of the smelter's power requirements would be generated using surplus North West Shelf natural gas. Beyond 1995, Collie coal would be used.

Estimates indicate that approximately 1.8 million tonnes of Collie coal would be required annually to meet the smelter's full power needs (SECWA, 1983). Based on this estimate and the intended early use of gas, power generation for the smelter over its thirty year projected life would

consume approximately 10% of the currently demonstrated Collie coal reserves.

Establishment of the proposed smelter would necessitate a substantial increase in the rate at which coal would be mined. The post-1995 coal demand arising from the smelter would represent an increase of approximately 50% over the 1984 level of Collie coal production.

Before such an increase in the rate of coal extraction occurred, it would be necessary to investigate the consequential environmental impacts.

9.2.3 BASIC RAW MATERIAL SUPPLIES

An important consideration in the assessment of any major project is the source(s) of the basic raw materials required for construction purposes. The siting and operation of quarries and pits to provide materials such as hard rock aggregates, sand, limestone and gravel have direct environmental impacts. The transportation of these materials, particularly by road, also has impacts (especially noise-related social impacts) and has cost implications for the wider community. Rehabilitation of the sites from which the raw materials are extracted is a further issue requiring attention.

Construction of the proposed aluminium smelter would require considerable quantities of these basic raw materials, for example:

- sand for concrete and as fill;
- hard rock aggregate for concrete, rail ballast and road construction; and
- (possibly) gravel and/or limestone for road construction.

The consequent environmental impacts could be significant. However, the proponent has provided no information on the basic raw materials required for construction and accordingly, the Authority recommends as follows:

RECOMMENDATION 18:

The EPA recommends that any significant potential environmental impact associated with the acquisition and transport of large quantities of basic raw materials to be used in the construction of the proposed smelter, should be referred to the EPA so that the environmental impacts can be assessed.

Based on its consideration of this information, the Authority would then liaise as appropriate with the relevant agencies concerning extraction of the required materials. The potential for transportation-related impacts would receive particular attention.

9.2.4 EFFECTS ON ALUMINA REFINERIES AND BAUXITE MINING

The principal raw material input to the production of aluminium metal is alumina (Al_2O_3). Each tonne of aluminium requires approximately 1.93 tonnes of alumina. In the case of a smelter with a capacity of 230000 tpa, this will consume 445000 tonnes of alumina each year (Helleman, Section 4.8).

Western Australia currently has four alumina refineries in operation: Kwinana, Wagerup, Pinjarra and Worsley. The first three are operated by Alcoa of Australia Limited while the last is operated by Worsley Alumina Pty Ltd. Alumina production and its value during 1984 is given in Table 15. Also included in this Table is the current capacity of each refinery and the total capacity that has been approved by the Government of Western Australia.

Kwinana and Pinjarra refineries have been developed to approved capacity while Wagerup and Worsley could at least double current capacity to achieve authorised maximum levels of production. In all cases, expansion beyond the approved total capacity would involve further environmental assessment of the proposals. This would require an assessment of not only the structural expansion envisaged but also examination of the environmental consequences of the expansion of bauxite mining in the Darling Range.

It is indicated in the ERMP (Section 7.5.1) that an expansion of alumina capacity as a consequence of smelter demand is not envisaged. This must either depend on the smelter diverting existing alumina production from export or require at least one of the alumina refineries to expand beyond current installed capacity. With approved total capacity for two refineries being significantly more than current capacity, this could be achieved.

9.2.5 PROVISION OF INFRASTRUCTURE SERVICES

Establishment of the proposed smelter would require the following services at the Kemerton site:

- rail access;
- road access;
- water supply;
- natural gas;
- power; and
- telecommunications.

Table 15 Western Australia Alumina Refinery Capacity and production (1984 calendar year)

	Current capacity (t)	Authorised maximum (a) capacity (t)	Production (t) (b)	\$ Value of production (b)
Alcoa of Australia Ltd				
KWINANA	1,600,000	6 units*	1,529,232	286,612,300
PINJARRA	2,600,000	5 units*	2,659,106	498,337,447
WAGERUP	500,000	2,000,000	459,021	86,832,066
Worsley Alumina Pty Ltd				
WORSLEY	1,000,000	2,000,000	357,629	69,073,857
TOTAL	5,700,000	8,200,000 +	5,004,988	940,855,670

* The authorised capacity of Kwinana and Pinjarra refineries relates to the number of production units rather than a tonnage. Output will vary according to the efficiency and technology of each unit.

+ Based on current unit capacity at Kwinana and Pinjarra.

Source : (a) Alcoa of Australia Ltd.
(b) Department of Mines.

Road access to the Kemerton site is available via Marriott Road, although establishment of the smelter as proposed would require re-alignment of this route. The Wagerup-Bunbury natural gas pipeline traverses the eastern sector of the Kemerton area, but a lateral take-off would be required to connect to the proposed smelter. Other essential services are not presently available on the site and provision of these would present the major source of biophysical impact. Particular impacts that could be expected would include:

- clearance of existing vegetation to make way for the services;
- disturbance of land forms and soils as a consequence of earthworks and clearing;
- possible spread of *Phytophthora cinnamomi* through earthworks and vehicular movements;
- disturbance of natural drainage patterns; and
- increased turbidity and sedimentation in natural drainage systems from dewatering during trenching.

The areas of greatest susceptibility to such biophysical impacts would be the Wellesley River and wetlands east of the Kemerton site.

As an adjunct to the smelter proposal, consultants commissioned by the WA Government and co-ordinated by the Department of Resources Development have examined options for alignment of a rail service corridor to the Kemerton area (Dames and Moore, 1985a). The consultants' report is assessed in Appendix D of this Assessment Report.

The Authority accepts that, based on the information provided by the consultants, the preferred option for the rail corridor (i.e. the Cactus Channel alignment) would minimise its biophysical impact. However, as indicated in Appendix D, until the actual siting and orientation of the proposed smelter have been finalised, the alignment of the rail corridor and, therefore, its likely consequences cannot be fully resolved.

Limited information concerning alignments of the other services required is available but again their location would depend on the ultimate position of the proposed smelter (Chapter 11). Therefore, information as to the likely impacts arising from provision of these services is also limited. This matter is addressed further in Section 11.2.

9.2.6 CUMULATIVE IMPACTS OF SO₂ SOURCES

Sulphur dioxide emissions from the smelter are reviewed in Section 7.2.18. Adverse cumulative or synergistic effects are unlikely.

9.3 CUMULATIVE SOCIAL IMPACTS

The developments proposed for the Bunbury/Collie area (Table 14) would generate a significant number of jobs during the construction and operational periods for each project.

Although this would increase employment opportunities for people resident in the Bunbury region, it could reasonably be assumed that a proportion of these jobs would not be filled from local sources. Thus new workers and their dependents would move into the region. A range of social impacts result from this population growth, and would require careful co-ordination and planning to ensure that the region experienced a net social benefit from the development.

Cumulative social impacts are most likely to occur in the areas of housing, community infrastructure demands, employment availability, traffic, financial impacts and quality of life changes. These are shown on Table 16 in terms of likely positive and negative manifestations. Possible ameliorative measures are also indicated.

These examples indicate that the size and timing of concurrent major developments are important factors in determining whether the cumulative impact would be positive or negative. Sequential or staggered development of projects could prevent the compounding of impacts associated with concurrent projects.

The demand for rental and other forms of temporary accommodation (particularly during the construction phase), and the consequences of such for tourism, are a practical example of the type of cumulative social impact that could arise from the smelter and other development proposals.

Although the proponent proposes to establish an accommodation camp for construction workers, it acknowledges that pressure on caravan parks and other tourist facilities would increase, particularly over summer. Concurrent developments would obviously compound this pressure. Any consequent reduction in the availability of tourist accommodation could extend over several peak tourist seasons, because of the duration of the construction projects.

9.4 BIOPHYSICAL/SOCIAL INTERACTIONS

Components of the biophysical environment can affect people in a variety of direct and indirect ways influencing, for example:

- their health and general well-being;
- the land use opportunities available to them; and
- their perceptions as to the quality of their life style.

Similarly, various social actions can produce biophysical impacts. Recreational pressures can, for example, result in degradation of environmental quality through erosion, reduced amenity, and loss of vegetation.

Fluoride impacts are an important issue arising from the proposed aluminium smelter, and the matter of compensation for such impacts was raised in many of the public submissions received. The proponent acknowledges the need for an appropriate compensation mechanism to be established.

An effective fluoride sink/buffer around the smelter should contain fluoride impacts to within manageable levels and reduce the likelihood of the occurrence of any significant fluoride impacts beyond the buffer zone. Nevertheless, as public concern is already evident, a mechanism for assessing complaints and providing compensation would be appropriate and accordingly the Authority recommends as follows:

RECOMMENDATION 19:

The EPA recommends that, in view of specific commitments by the proponent, a mechanism of compensation for fluoride impacts should be established and details provided in the EMP.

The South West Region contains a range of resources that would experience increased recreational pressure as a result of population growth, whether attributable to the smelter and associated development or other causes. These include:

- the coastal sector, beaches and nearby marine areas;
- the estuarine, riverine and other wetland systems;
- National Parks;
- State Forests and water catchment areas; and
- caves.

Recreational impacts already occur in these areas and would increase irrespective of the smelter proposal, for instance as a result of natural population growth and increased tourist activity. Establishment of the smelter and associated developments would, however, accelerate the rate at which the pressures would increase in the short term.

**Table 16 Examples of Negative and Positive Cumulative Social Impacts associated with Concurrent/Sequential Major Developments
(Derived from the literature)**

TYPE OF IMPACT	POSITIVE	NEGATIVE	POSSIBLE AMELIORATIVE MEASURES FOR NEGATIVE IMPACTS
Housing and community infrastructure demands	Could take up capacity created by the wind-down/out-migration of other project construction work force.	Could compound existing shortfalls associated with other project-related population increases.	• plan developments so that they interact in this area if possible. • proponent can provide housing and infrastructure (or funds for purchase) so problems do not develop. • arrangements made between proponent, Government and Local Authorities for funding of additional infrastructure.
Employment availability and cost	Could provide continuity of work for locally-based construction workers and increase diversity of job opportunities for total local labour force.	Could increase competition for and cost of local labour especially for industries with least ability to absorb increased labour costs	• plan developments so that they interact positively in this area if possible. • cost of labour difficult to control if new development pays better than for example, farm labouring.
Traffic impacts	Increased traffic volumes could amortise cost of major road improvements. Could help maintain or increase patronage of public transport.	Could create/compound bottlenecks associated with shift changes. Continued heavy traffic could compound drainage damage to roads and raise community rate levels.	• improvements to local roads. • increased funding to Local Authorities for road works. • restrictions on heavy haulage on some routes. • light vehicles access routes. • flexible work hours to spread traffic load. • properly maintained trucks to minimise noise.
Lifestyle community structure changes	Diversification of employment, entertainment and retail opportunities and demographic structure.	Adverse reaction to change from agricultural to industrial community. Continued and rapid rate of community change.	• monitoring by a Community Liaison Officer to identify problem areas early. • provision of on-going Community consultation.
Municipal financial impacts	Continued growth in municipal rate base	Demands for capital investment precede growth in revenue.	• need for front-end financing by proponent or Government to allow for delays in Local Authority budgeting.

7.10 SHIRE OF COLLIE

- The Shire of Collie wrote to the SECWA objecting to a section of the preferred corridor because of its effect on private property. The SECWA sent a copy of the Shire of Collie's letter and its reply to the Department of Conservation and Environment. The Authority is of the opinion that the criteria used for selecting the preferred corridor are sound and accepts the SECWA's arguments for not relocating the corridor as requested by the Shire of Collie. The Authority points out that the transmission line will need careful planning within the corridor to minimise potential impacts on private property.

7.11 SHIRE OF HARVEY

- Council supports the preferred routes and notes that the corridor from Harvey to Kemer-ton is situated west of irrigated land;
- interference with a private airstrip on Pt Lot 7 Wellesley Road should be avoided;
- SECWA should compensate Council for any deterioration of local, unsealed roads;
- agricultural values, especially on irrigated land should be maintained, therefore construc-tion should proceed on irrigated land over the summer;
- final transmission line route should minimise visual impact.

7.12 SHIRE OF WEST ARTHUR

- No comment.

8. CONCLUSIONS

The Public Environmental Report prepared for this project was the first PER assessed by the EPA.

The Authority introduced this level of assessment to fill a need in its environmental impact assessment process for public review of environmental analyses of proposals for which an En-vironmental Review and Management Programme is not warranted.

In the case of this proposal, the Authority considered that the separate environmental assessments being undertaken for the smelter project and other infrastructure elements cover many of the issues which would normally be addressed in an ERMP.

The PER for the project sets a commendable standard for such documents. Environmental considerations were incorporated at the start of project planning. Environmental issues have been addressed concisely but adequately. Potential impacts have been identified and, in general, acceptable management provisions delineated. This has made the Authority's task of reporting on the project considerably easier and is therefore reflected in this report.

The Authority believes that the project can proceed on environmental grounds subject to the commitments made in the PER and the recommendations in this report.

LEGEND

CONTENTS

1. SUMMARY
2. BACKGROUND
3. THE PROPOSAL
4. ALTERNATIVES
5. ENVIRONMENTAL IMPACTS AND MANAGEMENT
6. PUBLIC SUBMISSIONS
7. SUBMISSIONS FROM GOVERNMENT AGENCIES
8. CONCLUSIONS

P

PREFACE

This Appendix consists of the Authority's Assessment Report prepared on the Public Environmental Report on the Proposed Transmission Line Interconnections for Proposed Aluminium Plant (Kemerton) by the State Energy Commission of Western Australia (SECWA).

The report is included in this Assessment Report for completeness, as the PER relates specifically to an infrastructure component of the smelter. This Assessment Report was completed in June 1985 and has been forwarded separately to Government.

APPENDIX C
PROPOSED TRANSMISSION LINE INTERCONNECTIONS FOR
THE ALUMINIUM SMELTER

STATE ENERGY COMMISSION OF WESTERN AUSTRALIA

REPORT AND RECOMMENDATIONS
BY THE
ENVIRONMENTAL PROTECTION AUTHORITY

STUDY 3: EFFECTS OF FLUORIDE ON SOIL CHARACTERISTICS AND GROUNDWATER

Early results of laboratory tests carried out on soils from the buffer zone and smelter site show that the different soil types vary in their ability to remove fluoride from solutions leaching through them. The indications are that the effectiveness of soils in removing fluoride, in order of decreasing capacity is:

- Karrakatta yellow at a depth of 50-60cm;
- Karrakatta yellow surface;
- Karrakatta grey surface;
- Joel surface;
- Karrakatta grey at a depth of 50-60cm;
- Joel at a depth of 50-60cm;
- Gavin.

The characteristics of Jandakot sand for fixing fluoride have not been determined. Ground-up coffee rock from near the water table in Gavin sands has a high capacity to absorb fluoride but as undisturbed coffee rock is known to be relatively impermeable to water, and is unlikely to contribute much to fluoride removal.

Comparison of these results with information obtained in New South Wales for the Tomago Sands near Newcastle indicates that the Karrakatta yellow sands, like the Tomago Sands, are relatively effective in adsorbing* fluoride. In contrast, the Gavin sands, in particular, have a much lower fluoride-fixing capacity.

Observations on the limited ability of Gavin and Joel sands to take up fluoride accords with the understanding of the behaviour of phosphorus from superphosphate applied to these sandy soils in the catchments of the Peel and Harvey estuaries. A high proportion of phosphorus is leached by winter rainfall and is lost in solution to drainage waters rather than remaining in the soils.

Field and laboratory studies are to be used to extend this early understanding of the way fluoride behaves in the soils of the region. At this stage it appears that, given the low retention of fluoride by soils derived from the Bassendean Dune System, the potential exists for fluoride to move through the soils to shallow groundwater.

STUDY 4: FLUORIDE AND IRRIGATED PASTURES

Experimental work has not commenced. The site has been selected and a shed constructed. Progress awaits arrival and assembly of apparatus. However an anemometer has been installed to provide data on wind speed and direction at the site.

4. CONCLUSION

This Appendix has described studies initiated by the Authority and funded by the proponent and State Government to investigate the impacts of fluoride emissions on soils, groundwater, native vegetation and pastures characteristic of the buffer zone, smelter site and the Harvey region.

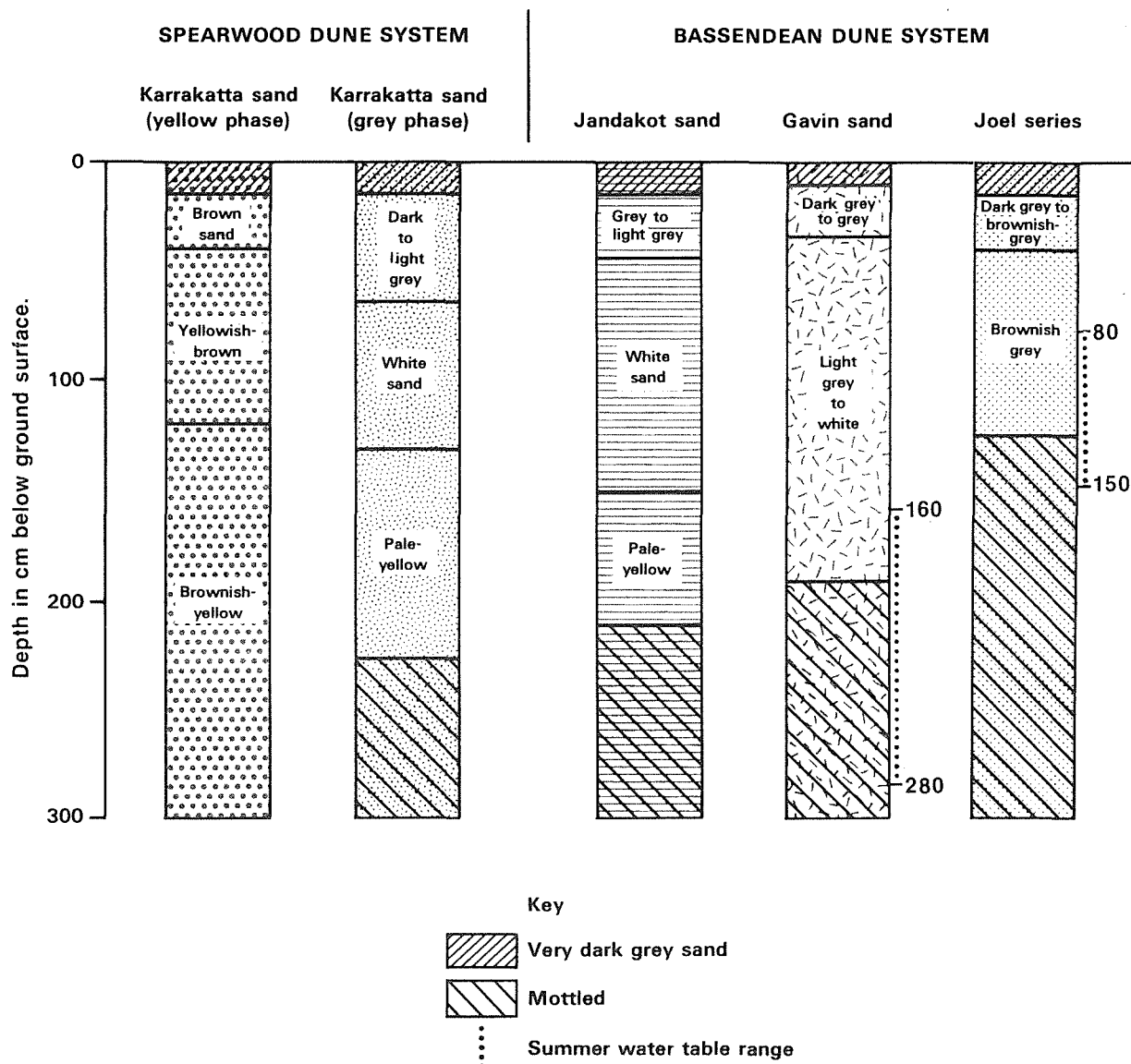
The soils of the proposed buffer zone and smelter site have been mapped and soil profiles described to a depth of three metres (Study 1). Column tests carried out on soils from the site give indications of the differing capacities of the soil types to absorb fluoride (Study 3).

Studies on the effects of fluoride emissions on native trees (Study 2) and on irrigated pastures (Study 4) are as at yet at an early stage and no results have been reported.

Results of the soil studies have the following implications:

- Joel soils which occur on the east of the proposed smelter site have water tables at about one metre below the surface in summer. For Gavin sand, slightly higher in the landscape than Joel sands, about half the soil profiles examined had water tables at about two metres below the surface in summer.
- Gavin and Joel sands have a very limited capacity to absorb fluoride, indicating that fluoride deposited on the soil surface would tend to be leached to the shallow groundwater.
- By inference, water tables in winter will be appreciably higher than those observed in mid-summer.

These results are relevant to the appropriate siting of the smelter, the treatment of runoff from impermeable surfaces, and the suitability of irrigation as a means of disposing of waste waters. The possibility of fluoride being leached to the surficial aquifer must also be considered.



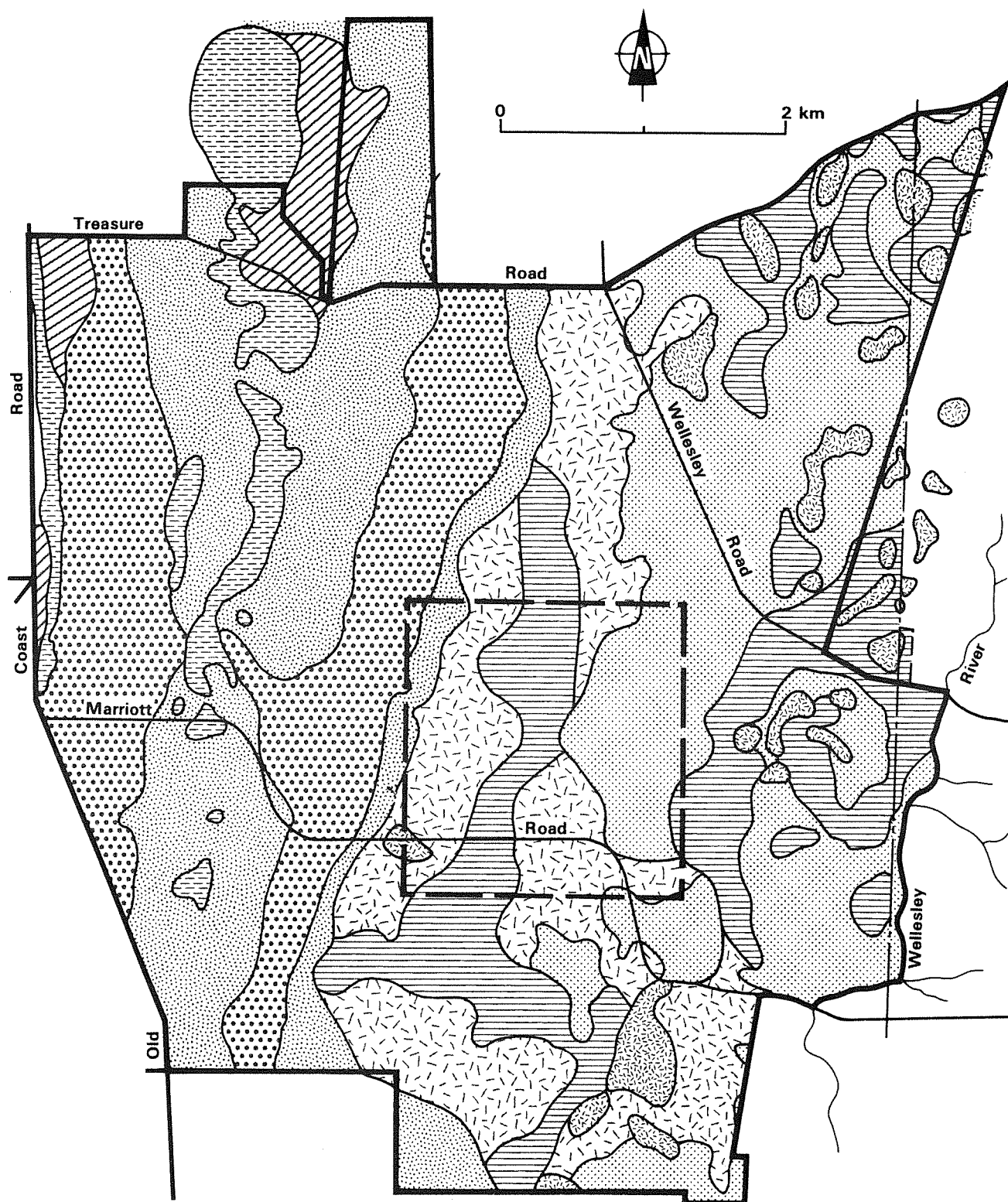
Source: Dimmock (1985)

Figure B-2 — Generalised Profiles of the Major Soil Units, Kemerton Area (source: Dimmock, 1985).

STUDY 2: EFFECTS OF GASEOUS FLUORIDE ON TREE SPECIES

The experimental work for this part of the study has not yet commenced. The site is now established and equipment assembled. Experiments commence towards the end of June. The experiments have been set up at a site remote from the buffer zone and smelter site but on soils of the Karrakatta Series. The conditions of soil and climate are such that results can be related with confidence to the buffer zone.

It has been possible to obtain young trees of two to three metres high for two species which are important components of vegetation of the buffer zone, west of the proposed plant site. These are tuart (*Eucalyptus gomphocephala*) and peppermint (*Agonis flexuosa*). Seedlings of jarrah (*E. marginata*) and marri (*E. calophylla*) will also be included. Predicted dispersion patterns of gaseous fluoride indicate ground level concentrations of less than 0.5 microgram of fluoride per cubic metre ($\mu\text{g F/m}^3$) for western parts of the buffer zone. The trees are to be exposed to gaseous fluoride in concentrations of 0, 0.3 and 0.5 $\mu\text{g F/m}^3$. The experiments will aim to determine the relationship between the concentration of fluoride in air and the rate of fluoride uptake through leaves, the effect of fluoride in air on growth, how fluoride taken up through the leaves is moved about in the trees and the relationship between the fluoride and other nutrient elements in the tree tissues.



Key		Spearwood Dune System	Bassendean Dune System
	Buffer boundary	Karrakatta sand (Yellow phase)	Jandakot sand
	Smelter site boundary	Karrakatta sand (Grey phase)	Gavin sand
		Swamp complex 1	Joel series
		Yoongarillup association	Swamp complex 2

Figure B-1 — Distribution of Soil Mapping Units in the Buffer Zone and Smelter Site.

ding the proposed aluminium smelter, fluoride concentrations in vegetation cannot be so readily predicted. Dairy cattle grazing on irrigated pastures to the east of the proposed smelter may be at risk from fluoride effects. Cattle are sensitive to fluoride and therefore susceptible to fluorosis*, but dairy cattle are particularly susceptible because they graze in the same area for many years.

A relatively good understanding exists about fluoride concentrations in pasture required to cause fluorosis in dairy cattle and economic damage to the dairy industry. Standards have been established which must not be exceeded if damage is to be avoided (Assessment Report, Section 7.2.1.1). If a clear relationship between fluoride concentrations in ambient air and fluoride levels in pasture could be established for the particular climatic conditions of the Harvey region, then future monitoring of fluoride effects on pastures would be much simpler and cheaper than otherwise, because atmospheric monitoring could replace regular pasture sampling and analysis.

Work on these investigations is at an early stage. Gaseous hydrogen fluoride will be released in the atmosphere just above the surface of irrigated pasture when the wind is within the predominant sector. Levels of the fluoride in the air above the pasture will be monitored at various distances from the source. Pasture samples will be taken from the areas around each measuring device. Between trials the pastures will be fed off to sheep in order to subject them to grazing pressure.

Ambient air fluoride levels and fluoride levels in vegetation will be examined to determine whether relationships exist between the two. The study will be carried out for a full year to take into account seasonal differences.

3. PROGRESS OF THE STUDIES

As the studies progress, Dr Hingston is holding meetings to keep study participants abreast of progress. Results of studies which have made significant progress were submitted to the Authority early in May to assist in assessment of the ERMP. These results were also made available to the proponent at this time.

Information on the progress of the studies is freely available to the proponent and a representative has attended a briefing session.

3.1 STUDY 1: SOILS AND VEGETATION

A report entitled A preliminary field assessment of soils and vegetation at the Kemerton site provides a soil map of the buffer zone and plant site and describes the structure of soil profiles to a depth of three metres. Native vegetation is described by species lists for each of the soil mapping units identified. With regard to the interpretation of the distribution and structure of soils on the site, the report is "preliminary" only in the sense that it is to form part of the larger report to be submitted to the Authority at the completion of the CSIRO studies. Much of the information from this report has been used in Chapter 4.

The report documents survey methods and provides descriptions of the soil profiles and characteristics. The distribution of the soil mapping units in the buffer zone and plant site are shown in Figure B-1. Figure B-2 illustrates generalised soil profiles for each of the major soil mapping units.

The soil survey was carried out using traverses, air-photo interpretation and examination and description of 124 soil profiles to a depth of three metres. Five major soil types (mapping units), each occupying 15 — 20 per cent of the combined buffer zone and plant site, and three minor units were recognised. The five major soil mapping units are:

- Karrakatta sand (yellow phase)) Spearwood Dune System
- Karrakatta sand (grey phase)) on the western side
- Jandakot sand) of the buffer zone and
- Gavin sand) smelter site; and
- Joel series) Bassendean Dune System
-) on the eastern side of the area

The study also identifies two important Swamp Complexes, one on the western side within the Spearwood Dune System associated with permanent swamps, the other associated with all the seasonal swamps within the Bassendean Dune System on the east.

Of particular interest in the soil profiles (Figure B-2) is the position of the various soil horizons* and the occurrence and position of water tables. Whereas water tables were not observed in the Karrakatta sands or in the more elevated of the Bassendean Sands (the Jandakot mapping unit), water tables were observed in about half of the Gavin soil profiles at about two metres depth in mid-summer, and in all the Joel soil profiles at between 80 — 150cm in mid-summer. An organic pan*, or 'coffee rock', occurs at about two metres in the Gavin sands and below about one metre in the Joel series.

Large plastic canopies supported by scaffolding are placed around young trees growing in the ground. Fluoride gas is generated and fed into the canopies at concentrations of 0.3 and 0.5 micrograms of fluoride per cubic metre, similar to those predicted around the proposed smelter. The trees will be continuously exposed to gaseous fluoride and hence will be exposed to a **worst case** environment at those levels of fumigation. Other trees, treated similarly in all respects except for the fluoride fumigation, provide a basis for comparison. Mr Horne will initially use two methods to measure the amount of fluoride in the air circulated to the experimental trees. One method is the accepted Australian Standard method (AS 2618.2 — 1984). The other is a new method devised by the Clean Air Section which promises to be more convenient whilst maintaining accuracy. Use of the two methods together will enable the new technique to be thoroughly evaluated.

A large number of tests are being made on the trees in the plastic canopies. Growth rates are measured together with fluoride levels and chlorophyll* levels. Observation of leaf damage and stomatal response* also provides measures of the plant responses.

OTHER STUDIES

As adjuncts to the major components of its study programme CSIRO has undertaken several ancillary investigations which will contribute to the overall understanding of the ecosystem. These include investigations of the rate of leaf litter breakdown in the presence of fluoride and on the rate of uptake of fluoride by seedlings.

2.2 MURDOCH UNIVERSITY

Study 3: EFFECTS OF FLUORIDE ON SOIL CHARACTERISTICS AND GROUNDWATER

Objectives: To study where, how and in which form fluoride is bound in the soil to assist in the understanding of the capacity of the soil to remove fluoride, of how much fluoride will reach the groundwater, and how fluoride might behave in the groundwater if it reaches it.

Researcher: Dr G E Ho

Dr Ho is conducting laboratory and field studies to simulate the impact of fluoride on soils occurring in the buffer zone and the smelter site. The simulations set out to determine both the short-term and long-term impacts (say over the life time of a smelter — about 30 to 50 years) of fluoride on the soil. He is being assisted in this task by the detailed soil mapping and characterisation carried out by CSIRO.

In the laboratory studies, batch tests are carried out to obtain a relationship between the amount of fluoride absorbed by soils from different parts of the plant site using various concentrations of fluoride and various times of exposure. Soil samples from the surface and at a range of boundaries in the soil profile are used.

Column tests are carried out with soils from the site packed into columns. These columns are leached continuously with water containing fluoride and provide a small-scale simulation of much larger experiments set up within the plant site. These field lysimeters consist of large concrete pipes sunk vertically into the soil. They will be watered regularly with known amounts of fluoride solution. Samples of the water which leaches through the soil in the lysimeters will be collected regularly and analysed to find how much fluoride is carried through the soil profile. At the end of a year, soil samples will be taken from various depths in the lysimeter to find out where and in what form the fluoride is fixed. As controls for the experimental lysimeters, others are set up in the same location and treated similarly in all respects except for the application of fluoride.

Where the water table is within two metres of the surface, another kind of field test is to be carried out near the proposed smelter site. In this test, known as a dispersion test, a hole in water-logged soil will be dosed with fluoride and tests will be made to find out how the fluoride disperses in the groundwater.

2.3 DEPARTMENT OF AGRICULTURE AND CLEAN AIR SECTION (DEPARTMENT OF HEALTH)

Study 4: EFFECTS OF FLUORIDE ON IRRIGATED PASTURES

Objective: To find out if a relationship can be established between levels of fluoride in ambient air and levels of fluoride in pasture.

Researchers: Mr M Mason and Mr R Horne

Although dispersion modelling studies (Department of Conservation and Environment, Bulletin 203) can be used to predict average fluoride concentrations in ambient air in the region surround-

of fluoride fumigation on irrigated pasture at Wokalup Agricultural Research Farm. Mr Bob Horne of the Clean Air Section of the Health Department is playing a major role in technical aspects of fluoride emission generation and monitoring in both the CSIRO and Department of Agriculture investigations.

It must be recognised that at least a full year of observations is necessary to take into account the range of seasonal conditions acting on natural and cultivated ecosystems. Much longer term observations are necessary to take into account year-to-year variations in climate. However, the need for studies at this scale will have to be assessed and taken into account in ongoing monitoring programmes.

2. THE STUDIES

2.1 CSIRO DIVISION OF FOREST RESEARCH

A commitment was given by CSIRO that, in view of the importance of the environmental and economic issues to the State, research staff would be redirected from their longer term strategic studies of native forest ecosystems as required to undertake parts of the study as a matter of urgency. The CSIRO studies are multi-faceted and include baseline investigations relevant to other study components.

The Authority gratefully acknowledges CSIRO's considerable contribution to the programme.

Study 1: FIELD ASSESSMENT OF SOILS AND VEGETATION

Objective: To provide basic information on soils and vegetation in the buffer zone and plant site.

Researcher: Mr G Dimmock

The study involves mapping the soils and vegetation of the area using field investigations and published information. Soil samples from the site are being analysed for soil physical and chemical parameters. This characterisation will include, for each soil horizon:

- depth;
- colour;
- consistency;
- particle-size distribution;
- bulk density;
- pH;
- conductivity;*
- organic matter;
- total nitrogen;
- acid-extractable phosphate;
- potassium;
- calcium;
- magnesium;
- sodium;
- iron;
- aluminium;
- total fluoride;
- acid-extractable fluoride; and
- buffer-extractable fluoride.

Study 2: EFFECTS OF GASEOUS FLUORIDE ON TREE SPECIES USING FIELD FUMIGATION

Objective: To measure the effects of gaseous fluoride on tree species of environmental importance in the region, under natural soil conditions and near-ambient conditions of light, temperature, humidity and rainfall.

Researcher: Dr F Hingston

Information on the sensitivity of native plant species to fluoride is limited — where it exists it is based on fumigation of seedlings and observations around brickworks. It is necessary to place the understanding of the effects on a firmer footing.

Local conditions can alter the effects of fluoride. For this reason, efforts are being made to carry out experiments under conditions as close as possible to those which occur naturally. For instance, near-natural conditions of soil, light, humidity, temperature and rainfall are provided in the experimental set-up.

APPENDIX B

ENVIRONMENTAL STUDIES BEING UNDERTAKEN FOR THE AUTHORITY

1. BACKGROUND

The limited time available for environmental approvals for the proposed aluminium smelter in the South West of Western Australia did not allow for long-term scientific investigations of the proposed site and the ecosystem that could be affected by the development. The Environmental Protection Authority recognised that there were many uncertainties about locating an aluminium smelter in a region without a good understanding of likely environmental effects. It therefore asked the proponent to fund a number of studies prior to the commencement of the assessment process. The Authority held the view that while much information is available from elsewhere, both in Australia and other countries, this information is specific to the locations in which it has been obtained.

There are features of the environment of the South West of Western Australia which concerned the Authority particularly. The soils have very low levels of nutrients and some are known to have a limited capacity to fix chemicals. On the coastal plain, groundwater in the surficial aquifers is an important resource but vulnerable to contamination. The long hot dry summers of the Mediterranean-type climate place both natural and cultivated ecosystems under considerable stress for a large part of the year. Litter decomposition rates are slow and remobilisation of pollutants by fire must be considered. All these factors indicate a need for caution in imposing additional stresses.

Recognising these problems the Authority took advice from Mr Frank Murray of the University of Newcastle, New South Wales on the nature of investigations required to provide better understanding of the environment of the preferred site. The outcome of the Authority's representations to Government on these issues was an undertaking by the proponent to provide \$130,000 for studies to be carried out for the Authority. Mr Murray was appointed as a consultant to the Authority and set about forming a study group.

The group includes:

- Dr Frank Hingston and co-workers, CSIRO Division of Forest Research;
- Mr Bob Horne, Clean Air Section, Department of Health;
- Dr Goen E Ho, School of Environment and Life Sciences, Murdoch University; and
- Mr Mel Mason, Department of Agriculture.

The Department of Conservation and Environment is facilitating and co-ordinating the studies. Dr Frank McKinnell and Mr John Bartle of the Department of Conservation and Land Management have assisted as advisers.

A portion of the funds provided by the proponent was directed towards the air dispersion and meteorology studies reported elsewhere (Dept. Conservation and Environment, Bulletin 203). The proponent has been kept informed of the progress of the studies and has had access to study results.

The thrust of the initial study programme was towards the soils, groundwater and native vegetation. The Authority also recognised a need to improve understanding of the effects of fluoride emissions on irrigated pastures. Accordingly representations to Government for funds have resulted in a joint investigation by the Department of Agriculture and the Clean Air Section of the Health Department on the effects of fluoride fumigation on irrigated pasture at Wokalup. This has been assisted by a portion of the proponent's grant which is being used for purchase of equipment.

The intention of the Authority in setting up the studies was twofold. Firstly, trends emerging from early results from the studies would be used to improve the basis of assessment of the environmental impacts of the proposed aluminium smelter (See Section 3). Secondly, longer term results, available after a year of study, would be used in framing requirements for the ongoing management of environmental effects.

The short lead time presented many difficulties in getting the studies off the ground. To design, purchase and construct apparatus, to engage staff, to obtain suitable sites and plant material and to obtain power sources takes many weeks. A devalued Australian dollar increases costs of equipment purchased from overseas. Study participants have to fulfil other work commitments. Some phases of the work, e.g. siting of the field lysimeters*, had to await baseline studies on soil types and groundwater levels. Such difficulties are being overcome, and all aspects of the studies are progressing.

The emphasis in the CSIRO studies is on investigating the effects of fluoride on native vegetation. Dr Ho of Murdoch University is studying the response of soils and groundwater to fluoride loading. Mr Mel Mason of the Department of Agriculture is undertaking a study of the effects

APPENDIX B
ENVIRONMENTAL STUDIES BEING
UNDERTAKEN FOR THE AUTHORITY

4.2 Definition of information needs

Only after the results of the above preliminary characterisation of the environment and proposal-environment interactions have been considered should baseline studies be undertaken. If sufficient initial understanding of the problem has been gained, the potentially important range of interactions between the proposal and the system should have been resolved and these should provide guidance on the most productive and necessary avenues for investigations.

It should be made clear how every individual study contributes to the understanding and the impact assessment of proposal-environment interactions. The results of these studies may result not only in a more precise determination of environmental impacts, but also in a revision of the relationships between components within the system.

4.3 Synthesis in the ERMP

The synthesis in the ERMP should clearly show how changes induced by the proposal would be transmitted through the ecological and social system to produce an impact (or effect) which is of concern or importance. It is often this transmitted or relayed effect which is more important than the direct effect on an individual species or environmental factor (such as water quality).

For a synthesis to be complete it should indicate:

- the predicted changes to the ecological and social systems which are of importance or concern;
- the likelihood of these changes occurring;
- the significance of these changes in a social, ecological and economic context;
- whether the changes are reversible; and
- the mitigating effects of environmental management.

5. WHAT ARE ERMP GUIDELINES?

ERMP guidelines are issued by the EPA (for proposals which require an ERMP) to assist the proponent to prepare an ERMP in accordance with the above strategy. The guidelines are prepared in consultation with the proponent and form a basis for discussion in the preparation of an ERMP. The guidelines are not prescriptive and the proponent may depart from them where warranted.

However, the ultimate responsibility for the content and presentability of the ERMP rests with the proponent, and therefore it is advised that the proponent liaise closely with the Department of Conservation and Environment to ensure the document is likely to be satisfactory.

When a proposal is subject to Commonwealth EIS legislation, the Department of Conservation and Environment ensures that guidelines incorporate the requirements of the Commonwealth.

Whatever variations of guidelines are used, it should be remembered that the ERMP should address the primary objective of identifying the principal environmental issues in terms of the alternatives proposed, present the assessments in a concise and accessible way, and contain details of ecosystem management and rehabilitation. This should improve the quality of decision-making through facilitating communication of the fundamental issues to decision-makers and the public.

However, it may not be necessary or even possible to quantify initially all the critical relationships in the system, but it is important to recognize the system as a whole and to understand how the proposal would interact with it. It is also important to recognise the natural systems are dynamic and have natural perturbations and resilience to stress. It is within this context that proposal-environment interactions should be examined.

In summary the construction of a conceptual model to aid initial understanding serves several important functions:

- if facilitates understanding the system;
- it organises the preliminary understanding of ecological structure and function;
- it provides direction and focus for subsequent studies and assessment;
- it promotes exploration of changes (environmental impacts) that may be induced by alternative proposals; and
- it provides a recognisable format within which to present the results of the impact assessment.

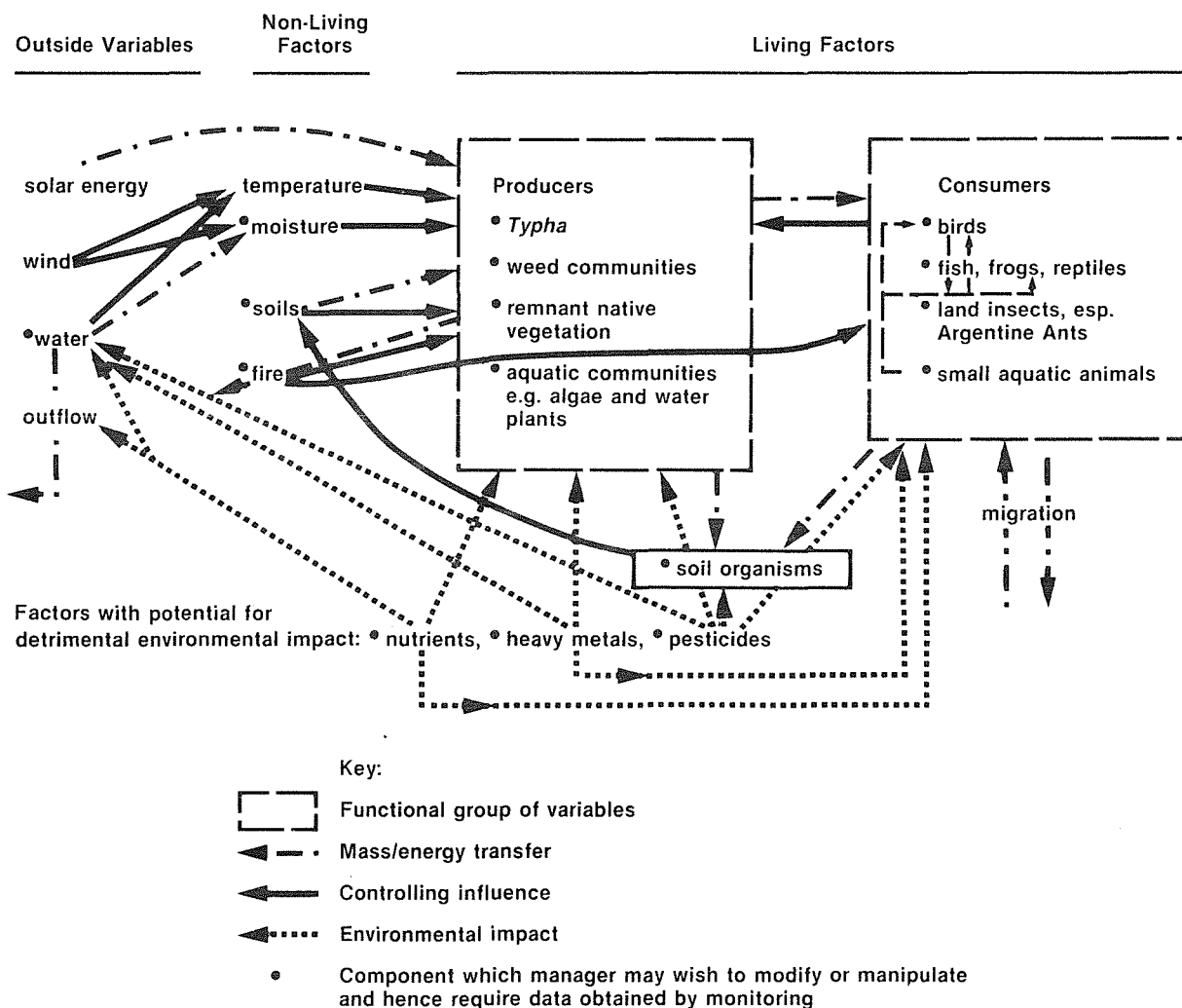


Figure A-1 — A Simple Conceptual Model of the Herdsman Lake Ecosystem.

- f) Time
- ii) Biotic Elements
 - a) Communities
 - b) Biomass — total organic mass
 - c) Producers, consumers and reducers
- iii) Energy Input and Utilization
 - a) Solar radiation for autotrophic systems
 - b) Chemical energy for heterotrophic systems
- iv) Nutrient Input and Recycling
 - a) Primary productivity
 - b) Secondary productivity

It should be possible to synthesize these factors into a conceptual model in particular cases as a basis for predictions of impact under various alternatives. An example of such a conceptual model is shown in the accompanying figure.

The emphasis in an ERMP should be on a prediction of the nature and state of the system following the implementation of the preferred and alternative development options and on the significance and acceptability of the induced change to the system and its components.

4. WHAT IS AN APPROPRIATE STRATEGY FOR THE PREPARATION OF AN ERMP?

The preparation of an ERMP requires knowledge from a wide range of disciplines. It is essential to maintain close and continuous iterative communication between the various consultants on the one hand, and between them and the regulatory authorities on the other hand. Such communication should occur at all stages, including:

- initial determination of the scope of the ERMP;
- definition of information needs;
- synthesis in the ERMP.

In short, it is essential that a holistic approach is adopted: this contrasts markedly with the traditional component approach to ERMPs (which often presented a long list of individual impacts, but rarely, if ever, synthesised these into a meaningful whole).

Such an approach will improve the assessment process through:

- inter-disciplinary communication during the assessment, and more constructive public participation;
- problem definition based on systems understanding;
- impact analysis based on improved understanding as fieldwork progresses;
- integration and synthesis of information; and
- sound environmental management throughout the life of a project.

This approach has far-reaching implications for consultants. Firstly, it will mean that consultants will have to co-operate and communicate regularly throughout a study. It will mean that as they go into fieldwork, they will have to select ecological variables which, when sampled, give some indication of how a system is performing and is likely to perform in the future under the proposed stresses. The approach would be based on a total appraisal of the ecosystem rather than on meaningless accumulations of descriptive data referring to isolated components.

4.1 Initial determination of the scope of the ERMP

The first step in the preparation of an ERMP is gaining a preliminary understanding of the social and ecological systems, and a first approximation of the interaction between these systems and the proposal.

By constructing a conceptual model (such as shown in the accompanying figure), it should be possible to determine:

- the geographical extent of the area subject to the impact assessment;
- how far into the future should the impact assessment predict;
- the important resources;
- the key biological processes such as major trophic relationships and driving forces such as climatic conditions and transport mechanisms; and
- the issues of concern or importance to the community.

NOTES FOR THE PREPARATION OF AN ERMP

1. WHAT IS AN ERMP?

The Environmental Protection Authority (EPA) of Western Australia gives advice on the environmental aspects of development proposals to the government, following the receipt of information from the proponent.

For many proposals it conducts its enquiries and offers its advice without public involvement.

However, for major or controversial proposals with the potential to alter the environment, the EPA requires the preparation of an Environmental Review and Management Program (ERMP). This is a public document which is required to focus attention on the environmental aspects of proposals. The document is prepared by the proponent (or his consultant), and should seek to demonstrate to the public and the EPA that the environmental risks and impacts can be kept within acceptable limits and managed throughout the life of the proposal up to, and including rehabilitation (where relevant).

ERMPs are the most sophisticated and detailed documents prepared for environmental impact assessment in Western Australia. However, the form and content of an ERMP will vary, from case to case, according to the type, magnitude, location and proposal characteristics. Nevertheless, in all cases, it should be concise and able to read and understand by the informed layman.

2. WHAT IS THE OBJECTIVE OF AN ERMP?

The principal objective of an ERMP is to present sufficient information to:

- promote public understanding of the proposal, thereby facilitating public response to the EPA;
- enable the EPA to give advice to government.

An ERMP also provide a mechanism for the public to raise issues which could not otherwise be raised.

The document should be prepared early in the planning stage of the proposal to ensure that appropriate environmental management strategies can be incorporated from the outset.

3. WHAT SHOULD AN ERMP CONTAIN?

In general, an ERMP will contain:

- a description of the preferred proposal, and alternatives which have been considered;
- a survey of the natural environment;
- predictions of the anticipated environmental risks and impacts which will arise from interactions between the proposal and the local ecological and social systems;
- an evaluation of the significance of such risks and impacts, and their acceptability;
- guidelines for environmental management and rehabilitation, and commitments to adopt these.

The EPA stresses that, in all the above, the document should focus on the principal elements: all background data should be placed in appendices.

The Guidelines now being issued by the EPA differ from those previously in use largely in the manner in which data is to be collected, analysed and presented.

The Authority is seeking new approaches based on the fundamental understanding of the structure and dynamics of ecosystems. The essential task will be to take an overview of the elements of the system involved and the external factors with which they interact and to present them as a synthesis or conceptual model which can be used to predict system behaviour under the stresses likely to be encountered. This represents a move away from component analysis to a synthesis of the components into a whole.

This will call for careful sampling of selected biological indicators rather than species lists and population counts which may describe the current status of systems, but not the future status under the induced stresses. Future environmental management will be based on the ecosystem rather than on individual species.

Although ecosystem modelling is, to some extent, subjective and will vary from case to case, a system will in general contain the following elements:

- i) An Abiotic Element — The Physical Environment
 - a) Temperature
 - b) Water
 - c) Light for photosynthesis
 - d) Topography
 - e) Chemical features of the habitat

changes to the character of the region, including social dislocation. The implications of a commuting work force (construction and operation stages) should also be addressed.

7. ENVIRONMENTAL MANAGEMENT

This section should outline the programme of controls, safeguards, and standards (particularly for fluoride emission to atmosphere) proposed to minimise or ameliorate adverse environmental impacts already described in the ERMP. The relationship between this proposal and the state government's proposal for the surrounding area should be made explicit as should the respective responsibilities for environmental management. The document should also address environmental management for decommissioning and site rehabilitation. The objectives, scope and details of the programme should be described. Particular attention should be given to the role of buffer zones in managing impacts.

Alternatively, if insufficient information to develop an environmental management programme (including management of social impacts) is available the proponent may outline a preliminary consideration of this matter, and subsequently submit detailed environmental management proposals for environmental and social management to the Authority for consideration.

Details of proposed waste management for the smelter should be included, particularly in relation to anode and cathode disposal from pot lines.

Assignments of responsibility for environmental management and its relationship to the proponents' management structure should also be stated. Baseline data collected as part of the description of the existing environment, and studies proposed to identify changes resulting from the proposed development should be included.

Emphasis should be placed on how the environmental and social management programmes will be adapted where necessary in the light of monitoring results. The document should indicate how results of the monitoring programme may modify smelter operations and management of the buffer zone.

The need for a social monitoring and management programme should also be discussed and appropriate recommendations and commitments given. This section should also summarise and where necessary, detail safeguards whether previously described or not.

The procedures for reporting results of monitoring and environmental and social impacts to the appropriate authorities should be outlined, and appropriate management measures proposed.

8. CONCLUSION

Conclusions of the overall impact of the proposal (including the role of ameliorative measures) should be stated together with an assessment of the environmental acceptability (including socio-economic aspects) of the project.

9. REFERENCES (Bibliography/Abbreviations)

GLOSSARY

Provide definitions of technical terms used. Also define and explain units of measurement which may not normally be understood by the interested layman.

ENVIRONMENTAL DOCUMENT GUIDELINES

These Guidelines, which have been approved by the Authority and the Commonwealth Department of Home Affairs and Environment, should be reproduced in the document.

APPENDICES

These may be produced as separate volumes or incorporated in the back of the document.

NOTES

- (i) These Guidelines should be used in the context of the attached document 'Notes for the preparation of an ERMP'
- (ii) These Guidelines have been prepared jointly by the Environmental Protection Authority of Western Australia and the Commonwealth Department of Home Affairs and Environment, for issue to the proponent for the preparation of the ERMP/Draft EIS.

To meet statutory Commonwealth requirements, the proponent will be required to respond to public comment in the form of a Final EIS.

Although it is not required statutorily to do so, the Authority will be also considering the Final EIS in the preparation of its Assessment Report.

the workforce requirements for such utilities and services. Associated development (infrastructure or service developments) such as accommodation, roads, transmission lines, sewerage, and communications should be described.

The additional requirements for social support facilities (e.g. schools, hospitals) should be outlined.

A detailed description of the smelter operations and processes including the supply and use of raw materials, water and energy should be given. The implications of the proposal for any expansion in bauxite mining (present and future) should be carefully analysed.

Also provide details of emissions to the environment and emissions control.

Details of workforce numbers and composition should be provided.

The potential offsite recreational impacts of the workforce should also be assessed.

5. EXISTING ENVIRONMENT

Ecological, physical, and social systems likely to be affected by all aspects of the proposal should be described but the document should concentrate on the significant aspects of the environment subject to impact from development.

In particular, the methods used to reach this appraisal should be given. Only the habitats, existing environmental quality, resources and potential resources and land-use which could be influenced by the project should be defined.

Detailed inventories such as species lists, and methods and experimental design used, should be placed in technical appendices.

Wherever possible conceptual models or diagrams should be provided to illustrate and synthesize the interactions between the physical and biological aspects of the habitats and resources and land-use discussed. Any relevant uncertainty in the functioning of the system should be noted. Discussion of the physical and biological processes that are the essential determinants of the maintenance of the various habitats and resources and land-use should be provided. An assessment of the resilience of these habitats and resources to natural and man-made fires, stream salinity, floods, raising or lowering of the groundwater table, disturbance of vegetation cover, and synergistic effects with other developments in the vicinity is required.

The discussion of the social environment should include information on regional economy, demography, land-use, planning, local industries, infrastructure, public and private utilities and facilities, Government support agencies, recreational facilities etc. Aboriginal site data can be placed either in this discussion, or if it is entirely of an archaeological nature it can be described as part of the physical environment.

Important features of existing agricultural land-use in the area should be outlined and particular attention given to those activities which are considered to be particularly sensitive to impact from development.

6. ENVIRONMENTAL IMPACTS

This is the most important part of the document, and should aim to show the overall effect on the total ecosystem, present and future land-use and social surroundings of the area. Before synthesizing the impacts in such a manner, it will be necessary to address the impacts on the individual environmental components. In all cases where an assessment is made, the criteria employed to assess impacts should be clearly stated. In particular considerable discussion should be provided on criteria employed to assess the effect of fluoride emissions and their confidence limits. Wherever possible effects should be quantified and uncertainties highlighted. The synthesis should also include an assessment of the significance and timing of the various impacts identified. For example:

- (i) it will be necessary to examine the construction stage separately from the operational stage, particularly in terms of social impacts
- (ii) some of the infrastructure or service developments (such as the power supply) will have little or no on-going interaction with the environment once they are established.

Where assessments are made of impact on natural or agricultural ecosystems based on experience in other areas, careful comparison should be made between the environment and practices in the two areas, so that the strength of the validity of the comparison is clear.

The document should also consider potential cumulative impacts (including the social impacts) in the context of existing and future developments (notably the state government's proposal for land-use in the surrounding area and the titanium dioxide plant), Bunbury 2000, and any other significant proposals, or developments currently under way in the Bunbury area.

The section should clearly indicate by reasoned discussion the impacts the development will have on environmental quality, land uses, resources (including energy requirements, mineral, water, soil and biological) and environmental amenity. It will also be necessary to address social impacts, and in particular this should include impact on community infrastructure and services, employment, population, potential conflicts between existing and incoming populations and any

APPENDIX A

GUIDELINES FOR AN ERMP/DRAFT EIS

SUMMARY

The document should contain a clear and concise summary of the salient features of the proposal, site location, alternatives, existing environment, the magnitude and extent of potential biophysical environmental impacts (including the confidence limits of such predictions), social impacts, environmental safeguards and management, and decommissioning and rehabilitation.

It would also be desirable for the proponent to make the summary available as a free-standing document to be available without cost.

1. INTRODUCTION

The document would include:

- background, objectives, and scope of the proposal;
- details of the proponent;
- scope and timing of the proposal;
- relevant legislative requirements and approval processes (State and Commonwealth);
- explanation of the purpose of the ERMP and why the document has been prepared. A brief description of the EIA process should be included;
- spatial relationship to other proposals ("SCM" titanium dioxide plant, transmission lines etc.), and land-use; and
- environmental interaction with other developments (present and future).

2. NEED FOR THE PROPOSAL

Describe in a general way the costs and benefits of the project to the proponent and community. It may be useful to describe these at local, State and National levels. Also describe the demand for new production capacity and within this context, the effect of the proposal.

3. EVALUATION OF ALTERNATIVES

The evaluation of alternatives is considered to be one of the more important parts of the document. A description should be given of how the project proposal has developed and the degree to which development alternatives have been examined.

Considerable attention should be given to the process of site selection, selection of technology and transport infrastructure options.

A description of the basic requirements of the development, relevant to site selection, should be given. Each site considered should be described sufficiently to provide an appreciation of its salient characteristics.

The criteria employed to evaluate sites should be described and the relative environmental and economic advantages and disadvantages of each site given. Discuss the reasons for the rejection or acceptance of each site.

In particular the rationale or criteria used in the evaluation of alternative technologies to achieve the objectives of the proposal should be given. Details of the technologies considered should be provided together with a demonstration of how each was appraised and compared on its relative physical, environmental and economic advantages and disadvantages. Consideration should be given to alternative technologies which are not just a modification of the same basic process.

Wherever options in technology exist, these should be explained. The potential impact of the "worst-case" technology should be evaluated, together with reference to the potential impacts of other options.

The aim of the review of site, technology and transport options is to lead the reader through the thought processes which have led to the preferred option along with the factors which control its present form.

The costs, benefits, and impacts of the "no project" alternative should be addressed.

4. THE PROPOSAL

The document should provide descriptions of the important elements of the development. It should cover the construction and operation phases.

The description should specifically include location and layout, development schedule, anticipated life of the project, utilities and services required. Reference should also be made to

APPENDIX A

PROPOSED ALUMINIUM SMELTER:

GUIDELINES FOR AN ERMP/DRAFT EIS

SULPHUR LOAD: Quantity of sulphur discharged.

SURFICIAL: i.e. Surficial aquifer. An aquifer either at the soil surface or shallow depth, which is not confined beneath impervious rock.

SYNERGISTIC: Tendency of chemicals and processes to react together to form possibly unforeseen combinations which may have a wholly new or markedly more powerful effect than the substances or processes taken separately.

TRANSPIRATIONAL: The loss of water vapour from a plant, mainly through the stomata (hence, transpirational loss).

VAPOUR PHASE: Gaseous form of a normally liquid or solid substance i.e. water.

VOLATILISATION: The conversion of a liquid or a solid into a vapour.

YILGARN BLOCK: An Archaean geological structure of granitic and other rocks occupying much of the southern half of Western Australia, of which the Darling Scarp marks the Western extremity.

GLOSSARY

- ADSORB:** To collect, as a gas or liquid, in condensed form on a surface.
- AEOLIAN DEPOSITS:** Rocks or sediments which have accumulated in a nonmarine environment and consist of essentially windblown sand or dust grains.
- ANODE:** Carbon block submerged in reduction cell (pot) to allow passage of electricity.
- ANODE EFFECT:** When the alumina content in the bath falls below 2%, gas builds up under the anodes causing high electrical resistance, normal cell voltages increase substantially and the reduction process virtually ceases. The resultant power increase to the cell raises the temperature of the bath and fluoride emissions increase.
- ARCHAEAN:** Term applied to the oldest Pre-Cambrian rocks in a region.
- ATTENUATE:** Taper off, and so narrow gradually to a point.
- BATH:** Molten contents of reduction cell (pot).
- BATH RATIO:** The ratio of sodium fluoride to aluminium fluoride.
- CARTBOTHERMIC:** Reduction using carbon.
- CATHODE:** Carbon lining of pot completing electrical circuit with anode.
- CELLS:** Reduction cell in which alumina is electrically reduced to produce aluminium metal.
- CHLOROPHYLL:** The green pigments present in the chloroplasts of all plants which are able to synthesize carbohydrates from carbon dioxide and water, utilizing energy derived from sun light.
- CONDUCTIVITY:** A measure of the amount of dissociated ions in solution, as determined by the quantity of electricity transferred under standard conditions, used to indicate salinity.
- CONSISTENCY:** Degree of density, esp. of thick liquids; firmness, solidity.
- CRETACEOUS:** The rocks which succeed the Jurassic and precede the Tertiary System (approximately 135-65 million years before present).
- CRYOLITE:** Sodium aluminium fluoride salt used as flux in electrolytic reduction of alumina.
- DENTIFRICES:** Powders, pastes etc. intended for tooth cleaning purposes i.e. toothpaste.
- DROSS:** Metallic oxides that rise to the surface of molten metal in metallurgical processes.
- ELECTROLYTIC REDUCTION:** Reduction of alumina to aluminium using an electrolyte i.e. the molten fluoride salts.
- ENDEMISM:** Quality of being prevalent in, and confined to, a particular country or district.
- FLUOROSIS:** Chronic poisoning with fluorine.
- FUME:** Cloud of airborne particles, generally visible, of low volatility and less than a micrometre in size, arising from condensation of vapours or from chemical reaction.
- GREEN CARBON:** Unbaked carbon consisting of calcined petroleum coke, pitch (coal tar) and anode butts.
- HALL-HEROULT PROCESS:** Method of producing aluminium by electrolytic reduction.
- HERTZ:** Number of cycles per second.
- ISOPLETHS:** Lines joining points of equal ground level concentration of given gaseous or settled particulate species.
- JURASSIC:** The middle division of the Mesozoic era (194-135 millions years before present).
- LENTIC:** Associated with standing water; inhabiting ponds, swamps, etc.
- LYSIMETER:** Device to house soil for studying the properties of the soil.
- MEDITERRANEAN CLIMATE:** Climate characterized by hot, dry summers and mild, wet winters.
- NECROSIS:** Of leaves — death of a cell (or of groups of cells) white still part of the living body.
- OPEN SWARD:** A short grass pasture (sward) in which the plant stems are spaced well apart (open structure).
- PHANEROZOIC:** An era of geological time; the last 570 million years.
- PH BUFFERING:** pH is a measure of the acidity or alkalinity of a substance. A substance (normally a solution) which resists changes in pH if acid or alkali is added, is said to be buffered or to have a high buffering capacity.
- POTLINE:** Two adjacent potrooms that are connected in electrical series.
- POTROOM:** Building containing cells connected in electrical series.
- PRIMARY EMISSIONS:** Airborne emissions from cells collected for subsequent treatment.
- QUATERNARY:** The most recent geological era and includes the Pleistocene and Recent Periods.
- REFRACTORY:** Material used in lining cells etc. to resist high temperatures.
- RODDING:** Anode rods are inserted in baked anode blocks and sealed with cast iron.
- ROOF MONITORS:** Roof vents for discharge of secondary airborne emissions.
- SCRUBBERS:** Apparatus or mechanism by which gaseous and particulate fluorides are removed from the waste stream.
- SCRUBBING:** Causes the removal of gaseous or particulate fluoride by changing the velocity of gas through alterations of direction and flow area of the gas stream.
- SECONDARY EMISSIONS:** Uncollected airborne emissions from cells, discharged through potroom roof vents.
- SOIL HORIZON:** A relatively uniform layer within the soil profile whose boundaries are normally horizontal or sub-horizontal.
- SOUND POWER LEVEL:** The total acoustic power generated by a noise source (with reference to 10^{-12} watts).
- SPENT:** Used.
- STACK:** Chimney for the discharge of air emissions.
- STOMATAL RESPONSE:** The change in the size of pores in the epidermis (skin) of a plant, particularly the leaves, in response to stimuli, so controlling the rate of exchange of gases and water vapour between the plant and atmosphere.

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12.4 ENVIRONMENTAL MANAGEMENT

The magnitude of the actual environmental impacts of the smelter would be dependent on its environmental management. This will be considered in detail in the Environmental Management Programme. As noted in Chapter 10 and Recommendation 21, further information will be required before the Environmental Management Programme can be prepared by the proponent. Of particular significance will be relevant design information and the results of the Authority Study Programme (outlined in Appendix B).

The latter will be pivotal in the resolution of several key unresolved matters (especially those relating to liquid and solid waste disposal) and accordingly the Authority makes the following recommendation:

RECOMMENDATION 30:

The EPA recommends that the Study Programme now in progress should continue as planned: the results obtained will be valuable in the preparation of the Environmental Management Programme. These studies address:

- field assessment of soils and vegetation;
- effects of gaseous fluoride on trees;
- effects of fluoride on soil and groundwater; and
- effects of fluoride on irrigated pastures.

The Authority has recommended (Recommendation 22) that in the light of the continuing need for input on environmental issues, the EMP should be prepared by the proponent in consultation with the Authority and the Department of Resources Development and when finalised should be published.

12.5 FINAL RECOMMENDATION

The Authority concludes and recommends as follows:

RECOMMENDATION 31:

The EPA recommends that the Kemerton area (i.e. the area addressed by the Conceptual Land Management Plan) is an acceptable location for an aluminium smelter subject to a series of recommendations including the following:

- the development and implementation of a land management plan for the buffer zone, which recognises its prime function as a fluoride sink;
- the adoption of the EPA's major recommendations;
- the adherence by the proponent to the commitments given (as summarised in Appendix K); and
- the development of an appropriate Environmental Management Programme.

11. ISSUES REQUIRING RESOLUTION FOLLOWING THIS ASSESSMENT

During the assessment of the smelter proposal it became evident that there are a number of issues that either cannot be fully resolved within the context of this Assessment Report, or which cannot be dealt with appropriately because they require additional information, or require further action or a decision by Government or the proponent. Some of these actions can be accommodated within the EMP or subsequent environmental assessments. However, others cannot and will require further attention from government agencies or the proponent.

11.1 LAND MANAGEMENT PLAN

A number of questions arise out of consideration of the Conceptual Land Management Plan. The Conceptual Plan, as proposed, does not specifically provide for the aluminium smelter and consequently parts of the Conceptual Plan would require review if the smelter is established (Forests Department, 1985). In this event, a detailed management plan, which includes consideration of the smelter, will be required. This will need to address matters such as:

- agencies responsible for management of the Government buffer, non-Government buffer and land with non-conforming uses;
- timing of buffer zone planting;
- groundwater aspects of establishing the pine plantation; and
- fire control.

In Appendix E the Conceptual Land Management Plan has been considered and a number of recommendations have been made. These are presented here, together with other specific recommendations on the Conceptual Plan.

Appendix E states:

"a substantial forest production area will have an effect on groundwater levels beneath and adjoining the area. In the case of plantations of fast growing trees, such as the pine species proposed in the Conceptual Plan these effects may be significant, particularly in the case of adjacent wetland areas, due to the high water demand of the trees."

The Authority therefore recommends:

RECOMMENDATION 25:

The EPA recommends that the Department of Conservation and Land Management monitors groundwater and wetland water levels both as a component towards ongoing management of the wetlands, and to assist in determining any long-term effects that the proposed pine plantation might have on the water regime of the Kemerton area.

The Authority notes the occurrence in the Kemerton area of eight gazetted rare plant species and the largest population, to date, of *Pultenaea skinneri* and therefore recommends:

RECOMMENDATION 26:

The EPA recommends that, in view of the known occurrence of rare and endangered species, a study be undertaken by the Department of Conservation and Land Management to identify those aspects of the floral communities in the buffer zone that have conservation value and may need appropriate management. This study should be completed prior to development in the Kemerton area.

RECOMMENDATION 27:

The EPA recommends that a detailed land management plan for the Kemerton area should be prepared and implemented as soon as possible. The provisions of this plan should be compatible with the operation of a smelter within the area, and should include an appropriate fire management plan.

11.2 INFRASTRUCTURE

Section 7.1 of this Assessment Report discussed some of the biophysical consequences of altered smelter orientation or relocation to a different site. There are implications for infrastructure elements which may then also require relocation resulting in environmental impacts which have not presently been assessed.

Some of the unresolved infrastructure issues are:

- detailed design and construction of the railway spur, including aspects such as the need for a level crossing or grade separation where it crosses the South West Highway, and

the Agreement would require the proponent to prepare an EMP and undertake reporting of the results.

In the event that an Agreement Act is not prepared and ratified, the Authority believes that the Environmental Management Programme should still be prepared by the proponent. Likewise, all commitments given by the proponent in the ERMP, the Supplement and responses to questions (listed in Appendix K) should apply whether or not there is an Agreement Act.

10.5 ENVIRONMENTAL MANAGEMENT AND MONITORING OBJECTIVES

Environmental impact assessments are based on predictions of what might be expected to occur in the future. As a consequence, management measures that have been agreed may prove to be ineffective, inadequate or unnecessary, and unexpected effects may arise which require remedial action.

Management of environmental components or impacts must be adaptive in its approach, integrating environmental understanding at the beginning and continuing through the life of a project. For this approach to succeed, it is essential that the actual effects of the project, both during its construction and operation, are closely monitored to enable management to be adjusted in the light of results. Monitoring is also necessary to ensure that agreed management is undertaken.

The objective of the management programme and the related monitoring programme should be to ensure that impacts of the smelter are identified and quantified, then managed in ways that ameliorate and minimise the impact. The programmes should be iterative and responsive to changing circumstances.

Mention has already been made of the need for the Environmental Management Programme to address issues identified in this Assessment Report (Recommendation 21).

Some issues that should be subject to a management and monitoring programme include:

- environmental supervision during construction and operational phases;
- compensation for impacts;
- water and groundwater management;
- liquid wastes;
- air emissions management;
- solid wastes;
- noise emissions management;
- co-ordination of responsibilities and activities;
- construction phase management;
- worker accommodation; and
- worker education in environmental management.

This list illustrates the broad range of environmental issues that arise as a consequence of a development such as the smelter. Further, the monitoring of these will assist in identifying those aspects that arise as a consequence of the smelter and those that are underlying trends and processes.

RECOMMENDATION 24:

The EPA recommends that the proponent takes the necessary management actions, prior to commencement of the construction phase, to achieve the environmental objectives stated in this Assessment Report.

- on-site incinerator for any combustible packaging material (Dept. Env. and Planning, 1981); and
- wet scrubbing of secondary fume (Dept. Env. & Planning, 1981).

10.4 THE ENVIRONMENTAL MANAGEMENT PROGRAMME

The Authority has prepared this Assessment Report in the knowledge that an Environmental Management Programme (EMP) would be prepared by the proponent subsequent to the ERMP. In view of the emphasis that the Authority places on the management and monitoring component of any project, the EMP is important in the environmental assessment process. As a consequence many of the recommendations and suggestions in this report refer to matters that will be and should be addressed in the EMP.

RECOMMENDATION 21:

The EPA recommends that the proponent prepare an Environmental Management Programme which addresses inter alia:

- any amendments to the proposal as described in the ERMP;
- relevant design information;
- all matters identified in this Assessment Report as needing consideration in the EMP;
- the application of the results of the EPA Study Programme to project design and management;
- proposals for environmental monitoring and management including contingencies;
- mechanisms for the modification of management during project interruption at any stage;
- proposals for environmental management during project interruption at any stage; and
- proposals and/or commitments for decommissioning and rehabilitation.

Given the significance that will be attached to the EMP, dealing as it will with many aspects of the project that would normally be addressed in the ERMP, the Authority will have a continuing role in the preparation of the EMP as well as following the future operation of the smelter and the environmental effects that might arise from the smelter.

RECOMMENDATION 22:

The EPA recommends that, in the light of the continuing need for input on environmental issues, the EMP should be prepared by the proponent in consultation with the EPA and the Department of Resources Development, and when finalised should be published.

Management and monitoring of environmental impacts is a dynamic and iterative process which not only involves the proponent but must include other interest groups. To ensure that all groups are appraised of the results of the management and monitoring programmes and can participate in the development of future proposals, the programmes need to be the subject of regular reports and reviews.

Three levels of reporting are proposed by the Authority:

- immediate reporting to the Department of Conservation and Environment of unexpected events, such as spillages and excessive emission events;
- annual reporting of environmental management and monitoring programmes; and
- triennial reports.

RECOMMENDATION 23:

The EPA recommends that the proponent submits reports to the EPA on the monitoring and management programmes as follows:

- an annual report reviewing the year's progress on environmental monitoring and management, outlining proposed changes to the current three-year programme; and
- a triennial report in which the previous three years' environmental monitoring and management are reviewed, the proposed programmes for the forthcoming three years are presented, and proposed amendments to the EMP are detailed.

The Authority has recommended earlier (Recommendation 21) that the EMP should include environmental management and monitoring (including contingency) proposals. In view of this, the EMP should also present the first triennial proposal.

It is usual for projects of this size and nature to be subject to a specific Agreement Act. An Agreement is entered into between the State Government and the proponent which provides a framework that sets out the rights and obligations of the two parties. The ERMP suggests that

10. ENVIRONMENTAL MANAGEMENT AND MONITORING

The environmental assessment process in Western Australia places a high priority on the management of environmental impacts and the comprehensive monitoring of both the management programme and the impacts, to ensure that all appropriate steps are taken to ameliorate and minimise impacts.

10.1 ENVIRONMENTAL MANAGEMENT AND MONITORING FOR THE SMELTER

The decision to locate the aluminium smelter at Kemerton was made by the proponent in late 1984 and, as a consequence, there was insufficient time prior to release of the ERMP for the proponent to obtain all relevant environmental base information. Without such information the proponent was unable to give full consideration to many aspects of environmental management.

The proponent agreed that this would be overcome by:

- giving preliminary consideration only of proposed environmental management in the ERMP;
- the proponent funding additional studies to investigate important areas of uncertainty; and
- a management programme being prepared by the proponent at some later date, in the form of an Environmental Management Programme (EMP).

An integral component of the proposed EMP is the studies that are being currently carried out by the Authority. The intention of these studies is twofold:

- to permit trends that emerge from early results of the studies to be used in this Assessment Report; and
- longer term results (at the end of 12 months) which would be used in the framing of the Environmental Management Programme.

Further details of the studies being undertaken and results presented to date are presented in Appendix B.

10.2 ENVIRONMENTAL MANAGEMENT IN THE ERMP

Section 6 of the ERMP provides a preliminary description of environmental management. Much of this is based on emission controls and waste management, issues that are not necessarily site specific.

The proponent also gave commitments to undertake and investigate various environmental management measures. In many instances, these will be addressed in the EMP. Additional commitments were given by the proponent in the Supplement to the EIS and in responses to questions from the Authority and government departments.

A list of all commitments given by the proponent is provided in Appendix K.

10.3 DESIGN STAGE AND ENVIRONMENTAL MANAGEMENT

The Authority believes that, during the design stage, the proponent should investigate all appropriate technical means available to reduce and control all emissions and report on them in the EMP.

In the case of air emissions, the Authority notes that other reports have identified the following possible control means:

- stainless steel rather than aluminium hoods (Dept. Env. & Planning, 1981);
- potroom dry scrubbers which have collection efficiency greater than 99.5% (US EPA, 1980);
- the exhaust system to each pot capable of being boosted to supply extra air flow when a cover or covers are removed (Dept. Env. & Planning, 1981);
- anode bake furnace scrubbers with efficiency above 99.5% (Alcoa and Kinhill Planners, 1980);
- the anode butts cooled under special primary collection hoods within the potroom (if cooling anode butts are shown to be emitting fluorides) (US EPA, 1980);
- the fume collection system designed for retrofitting of secondary air pollution emission control if such controls become necessary (Dept. Env. & Planning, 1981);
- adequate standby and reserve equipment for collection and treatment of emissions, i.e. bag filter units, fans, pumps and feeders (Dept. Env. & Planning, 1981);
- undertake a smelter maintenance programme that deals with emission collection and treatment to minimise the down time or time when the treatment system is not fully functioning (US EPA, 1980);

It is important that the agencies responsible for managing public areas which already experience recreational pressures (or are likely to in the future) recognise the need for appropriate action in advance of increased impacts.

Because of the direct environmental implications of the anticipated increase in recreational pressures, the Authority recommends as follows:

RECOMMENDATION 20:

The EPA recommends that, in anticipation of increased recreational activity and consequent environmental impacts, relevant State and local government agencies should formulate appropriate strategies.

APPENDIX D INFRASTRUCTURE REQUIREMENTS OF THE ALUMINIUM SMELTER

APPENDIX D

INFRASTRUCTURE REQUIREMENTS OF THE ALUMINIUM SMELTER

1. INTRODUCTION

The ERMP outlined, in Section 3, the criteria used by the proponent to determine the location of the smelter. Among these were the following:

- proximity of location to assured long-term supplies of reasonable cost electrical energy. The available price of electricity will normally reflect energy, generation and transmission costs, the last generally increasing with distance;
- proximity of location to assured supplies of alumina, which is a major input to the production of aluminium. A location close to a suitable source of alumina should achieve transport cost saving; and
- the capital and operating costs of such physical infrastructure as power generation and transmission equipment, rail and road links and port facilities have a major impact on the economic viability of an aluminium smelter.

Clearly infrastructure provision is an important aspect of any major development, including the aluminium smelter. Each component is an integral part of the complete project and should, therefore, be subject to review and assessment as part of the whole development.

Marriott Road is the only form of physical infrastructure that is located within the proposed smelter site. All other services need to be provided.

This Appendix discusses many of the infrastructure components required by the proposed aluminium smelter. Provision of power to the smelter site has already been discussed in Appendix C.

2. SERVICES CORRIDOR STUDY

As with several other aspects of the proposal to establish an aluminium smelter at Kemerton, the provision of infrastructure was not dealt with in any detail in the ERMP, but rather some components have been outlined in a separate Government document, prepared by consultants to the Government and co-ordinated by the Department of Resources Development.

2.1 OUTLINE OF STUDY

The Aluminium Smelter Services Corridor Study (Dames and Moore, 1985) was prepared at the request of the Authority to assist with identification of physical and social environment impacts in relation to the provision of services to the Kemerton smelter. It was specifically intended to facilitate selection of a cost-effective railway alignment, to consider options for achieving a safe rail crossing of South West Highway and to assess the scope for providing other services within the proposed rail corridor. Due to the location of the smelter site, the study concentrated on the identification of possible corridors from the Wellesley River to the South West Main Line railway between Bengier and Brunswick Junction.

2.2 INFRASTRUCTURE LINKS EXAMINED

Infrastructure links considered in the Corridor Study were:

- railway;
- road;
- water supply;
- natural gas; and
- telecommunications.

As the railway has major design constraints and least flexibility for change, evaluation of corridor options concentrated around the selection of a suitable railway route.

The possibility of locating the railway in conjunction with the proposed SECWA transmission line from Muja was reviewed but not considered to be feasible. The major reasons presented in the Corridor Study for this were:

- electric and magnetic fields produced around transmission lines can interfere with radio communication, telegraph and signalling facilities, thus affecting safe railway operations;
- the possibility of an accident where transmission lines fall onto the railway is such that construction in close proximity is to be avoided; and
- to achieve sufficient separation between a railway and a transmission line to overcome the above problems would require parallel easements of 40m and 60m respectively. Such

a 100m wide corridor would seem to defeat the concept of minimising physical and aesthetic disruption, which the common easement approach seeks to promote (Dames and Moore, 1985).

Based on previous experience, the consultants preparing the Corridor Study considered it unlikely that a single road would be effective in reducing the effects of traffic generated as a consequence of the construction and operation of the smelter. Departure and original destinations will be diverse and it would be expected that a variety of routes would be used, particularly within the Shire of Harvey.

The ERMP indicates that water supplies are expected to be obtainable from aquifers beneath the smelter site.

The existing natural gas pipeline to Bunbury passes through the Kemerton area. The necessary lateral to the smelter site would only be approximately 1 kilometre in length.

Telecommunications can be supplied either by microwave link to Bunbury or underground cables. The former would have minimal impact and the latter would have limited and transitory effects on the environment. The Corridor Study concludes that restriction of communication links to a services corridor would not be appropriate.

Port facilities would be required by the smelter. Further discussion of this is given in Section 3.3 of this Appendix.

2.3 RAILWAY CORRIDOR OPTIONS

A total of nine options for a railway alignment were considered in the Corridor Study. These are outlined in Table D-1 and illustrated in Figure D-1.

It is important to note that the Corridor Study did not consider corridor options within the Kemerton area.

The following recommendations were made in the Corridor Study:

- railway access can be provided with the least disruption to properties, land use and residents by selection of the Cactus Channel route option;
- land disruption can be minimised by incorporating that section of Beaufort Drain which parallels the channel, into a common easement with the railway spur. Wherever possible this easement should be limited to 40 metres, and should utilize the existing drain reserve as appropriate. Suitable provision for curves must however be allowed for;
- the opportunity to share common roads for access to the track, drains and channels should be pursued by the relevant authorities, with suitable provision for their respective operational requirements;
- careful consideration should be given to the potential impact of a railway on the householders at the junction of Wellesley Road and Beaufort Drain. If deviation around this house is likely to result in ongoing noise disturbance and property severance, it may be preferable to both the owners and Westrail, for Westrail to purchase the house;
- consultations with all relevant authorities and affected landowners should occur on an ongoing, as required basis;
- one of the most sensitive issues will be provision of a crossing of the railway spur by the South Western Highway. On the available information, deviation of the highway to the central or western alignment shown on Figure 4 (Figure D-1 in this Appendix), with a suitably protected level crossing, appears to be the best solution. This recommendation should be kept under review as detailed design proceeds to allow selection of the preferred alignment;
- adequate road access to both the east and west of the site will be required prior to smelter construction. On balance, it is recommended that existing routes be upgraded. Detailed selection of routes requires more information on demography and likely sources of construction materials. These aspects should be subject to detailed consultation between the Shire of Harvey, the project proponents and the relevant government authorities; and
- all other services are best provided on site or independently of the service corridors discussed in this report. (Dames and Moore, 1985, p.32.)

3. COMMENTS

3.1 INFRASTRUCTURE

The Authority is of the view that the environmental implications of any project can only be determined by subjecting all aspects of the proposal to close scrutiny. Where the effects are likely to be contentious or significant, there is a clear need to involve the public in this process.

Table D-1 Options Considered for Eastern Services Corridor

CORRIDOR OPTION	APPROX. LAND REQUIREMENT	APPROX. LENGTH TO LAND MANAGEMENT BOUNDARY	DRAINS/ CHANNELS AFFECTED	NUMBER OF STRUCTURES AFFECTED		SECONDARY ROAD CROSSINGS	INTER- PADDOCK BRIDGES	LOTS SEVERED	COMMENTS
	(1)(ha)	(km)	(2)	BUILDINGS	DAMS	(3)			
ROAD 3030	47	11	1	6	1	2	—	1	Passes through swamp area, adjacent to special rural zone.
WELLINGTON	51	12.5	1	6	2	2	—	1	Crosses transmission line at 40° angle. Passes through swamp area.
PARTRIDGE	27	6.5	7	25	4	2	14	1	Residences both sides of Partridge Road.
CACTUS	25	6.2	5	1	1	1	0	0	Few trees bordering channel. Large farm lots.
BUTTERCUP — D	26	6.7	8	11	1	3	2	4-5	Numerous trees bordering 'D' drain. Transmission line nearby.
CRANE	26	7.2	4	10	2	3	9	3-4	Sterilization of land between railway and channel. Transmission line nearby.
MELVILLE	26	6.6	5	13	1	3	13	4-5	Housing on both sides of the road. Transmission line nearby.
MARRIOTT	26	6.9	7	7	2	2	4	1-2	Assumes Crane-Buttercup route in common. Proximity to transmission line.
ELVIRA	40.4	10.2	—	—	—	9	—	—	Crosses over nine secondary roads and two main rivers.

(1) To edge of Land Management Site

(2) Includes Wellesley River as a drain

(3) Does not include South West Highway

(-) Not assessed.

Source: Dames and Moore (1985)

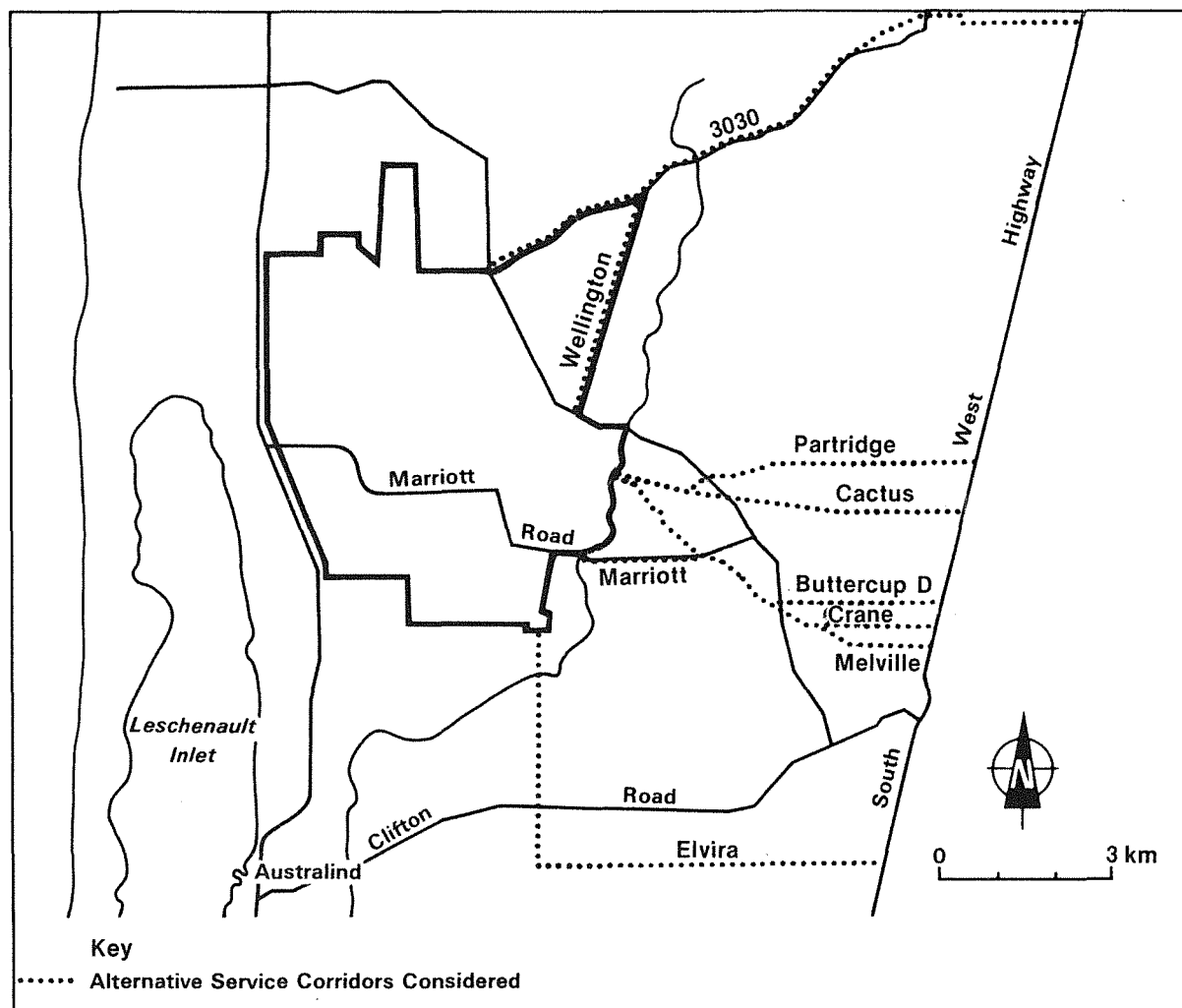


FIGURE D-1 Location of Options Considered for Eastern Services Corridor.

Source : Dames and Moore (1985).

When the ERMP was being considered for public release, the Authority noted that a separate public document to address infrastructure requirements of the smelter was intended. One report, the Public Environmental Report on the "Proposed Transmission Line Interconnections for Proposed Aluminium Plant (Kemerton)", had already been accepted for release concurrently with the ERMP. Comment on this report is provided in Appendix C.

The Authority indicated that a similar document on infrastructure components should be prepared by the State and released to the public during the ERMP review period. Of particular concern to the Authority was the need to co-ordinate the provision of the services in order that the impact of them could be minimised. This could be achieved by limiting the number of service corridors to the smelter. One was already proposed in the transmission line PER and because technical problems might preclude transmission and railway lines running continuously for any distance, it was clear that at least one additional corridor was required, for the necessary rail connection to the smelter. It was envisaged by the Authority that this document would not only include consideration of those services to be located within the corridor but should mention those services to the smelter that could not or would not be part of the corridor, such as port facilities.

The Corridor Study was released on 17 April, to coincide with the last two weeks of the public review period of the ERMP.

3.2 DISCUSSION OF THE CORRIDOR PROPOSAL

The Corridor Study is a first stage analysis of the means by which service connections from the east of the smelter site can be consolidated. It is likely that only two major services would be required from this direction, power lines and the railway. Each will have a separate corridor although only the railway requires acquisition and substantial alteration of the landscape.

The railway alignment preferred in the Corridor Study has not been subject to any detailed geotechnical or other investigations and can, therefore, only be considered as preliminary at

this time. Based on the information provided in the Corridor Study and summarised in Table D-1, the Cactus Channel option appears to minimise the effects on the biophysical and social environments. Most other routes would cause significant social disruption.

Several specific aspects of the corridor proposal require further comment. As indicated in the Corridor Study recommendations, the means by which the railway crosses the South West Highway will be a sensitive issue. The Corridor Study has indicated a preference for a level crossing on either the central or western alignment. Given the nature of the topography of this area, any embankments or bridge structures will be highly visible on the landscape. In addition, the projected use of the railway is such that interference to road traffic would be limited and of short duration. In terms of environmental implications, the Authority would favour a level crossing along the central highway alignment as this would minimise disruption to existing land uses. However, it is appreciated that public safety factors are paramount and this may require grade separation.

The Authority has indicated in Section 7.1.1.1 that the shallow groundwater on the development site constitutes a major constraint which will, at the very least, substantially change the site preparation requirements. At worst this could entail a change of orientation of the potlines on site which, in turn, would require a reassessment of the services corridor options and the location of other infrastructure components, such as the SECWA substation.

Until the plant site and orientation are finally determined, the recommended location of the services corridor from the east can only be considered as preliminary.

RECOMMENDATION 28:

The EPA recommends that any significant potential environmental impact associated with the alignment, construction or operation of the railway should be referred to the EPA so that the environmental impacts can be addressed.

As mentioned earlier, the Wagerup — Bunbury natural gas pipeline passes through the Kemer-ton area. The Authority's desire to reduce the number of service corridors to the proposed smelter should be applied to the required pipeline lateral. The railway corridor provides an opportunity to achieve this.

RECOMMENDATION 29:

The EPA recommends that consideration be given by SECWA and Westrail to locating the proposed natural gas pipeline later within the proposed railway easement to the aluminium smelter, and the SECWA continue to liaise with the EPA.

3.3 PORT REQUIREMENTS

When the Authority sought the preparation of infrastructure documentation, one component mentioned was the requirements of the smelter for port facilities. This had been briefly mentioned in Section 4.10.1 of the ERMP, where augmentation of shore-based infrastructure was seen as being necessary.

Several recent studies have examined future requirements of and demands for port facilities at Bunbury. These include the Bunbury Port Strategy (Bunbury Port Authority/Co-ordinator General of Transport, 1984) and the Bunbury Port Industrial Area Study (T.S. Martin & Associates, 1984). Included in the former study is a review of the implications of an aluminium smelter on port facilities. The conclusion reached in this study was that:

“... the port will be able to comfortably handle the smelter trade over the existing general purpose berth without the need for any major redevelopment such as a new berth’ (Bunbury Port Authority/Co-ordinator General of Transport, 1984, p. 46).

Although berth expansion will not be necessary, the smelter will require the establishment of a range of new facilities associated with the unloading, loading and storage of raw materials and aluminium metal. The impact of the development of these facilities has yet to be determined, but they may raise environmental issues.

In the event that any environmental impacts are identified, details of proposals for loading, off-loading and storage facilities at the Port of Bunbury should be provided to the Authority.

REFERENCES:

- BUNBURY PORT AUTHORITY/CO-ORDINATOR GENERAL OF TRANSPORT (1984). Bunbury Port Strategy.
- DAMES AND MOORE (1985). Aluminium Smelter Services Corridor Study.
- T.S. MARTIN & ASSOCIATES (1984). Bunbury Port Industrial Area Study.

APPENDIX E
CONCEPTUAL LAND MANAGEMENT PLAN -
KEMERTON AREA
FORESTS DEPARTMENT

APPENDIX E CONCEPTUAL LAND MANAGEMENT PLAN — KEMERTON AREA FORESTS DÉPARTMENT

1. INTRODUCTION

An essential component of the management of fluoride emissions from an aluminium smelter is the need to protect surrounding land users. Some fluoride would be given off from the plant irrespective of the technology adopted. The normal practice in Australia and elsewhere has been for the developers of an aluminium smelter to manage, through acquisition, land that is most likely to be adversely affected by fluoride emissions. This 'buffer zone' will vary in size according to a range of factors, including the specific characteristics of the smelter site and the nature of the surrounding land uses.

The Western Australian Government announced late in 1984 that it proposed to acquire the property known as 'Kemerton' from Alcoa of Australia Ltd and would purchase additional nearby land to provide for a major forestry, conservation and recreation initiative. As outlined in the ERMP, the Government indicated to the proponent that the proposed aluminium smelter could be located within this proposed development.

A conceptual management plan was subsequently prepared by the Forests Department (now the Department of Conservation and Land Management) and released for public comment on 7 March.

Although the Conceptual Land Management Plan acknowledges that an aluminium smelter could be established at Kemerton, it does not specifically provide for the smelter as the intention of Government is to implement the plan irrespective of whether the smelter proceeds or not.

2. CONCEPTUAL LAND MANAGEMENT PLAN

The Conceptual Land Management Plan (referred to as the Conceptual Plan) covers an area of approximately 3,600 ha, and is referred to as the Kemerton area (Figure E-1).

2.1 LANDSCAPE DESCRIPTION

An outline of the physical characteristics of the site has been provided in Section 4.2 of this Assessment Report. Briefly, the area consists of a series of sand dunes in the western half and broad undulating plain to the east. A number permanent and semi-permanent wetlands are found throughout the area. Open forest of jarrah, marri, tuart and peppermint still covers a major portion of the dunes, whereas most of the plain has been cleared for agriculture.

The land is described in the Conceptual Plan as:

"a subdued landscape which has been extensively altered by agricultural land use. Much of the original woodland and forest cover has been progressively lost to pasture development while portions of the wetlands (particularly to the north of Kemerton) have been drained and placed into cultivation. In the remaining areas of woodland, timber cutting coupled with frequent fires, grazing and the invasion of introduced grasses have further altered the landscape' (Forests Department, p. 4).

2.2 LAND USE PROPOSALS

The Conceptual Plan indicates that the management proposals for the Kemerton area are, insofar as is practical, designed to complement the inherent character of the surrounding landscape. Specifically, the land management programme proposes the following:

- development of appropriate recreation facilities in an area where there are limited facilities at the present time. Two developments are proposed, day use facilities focussed on the Wellesley River and a system of walking trails around the southern extension of Mialla Lagoon;
- retention of the amenity value of significant forest and woodland areas. The remnant tracts of forest and woodland situated between the Coast Road and the Mialla Lagoon wetland chain would be retained and managed for their amenity and conservation value;
- conservation of the chain of wetlands would be provided through protection from further clearing and drainage works. Access by both livestock and the public would be carefully controlled. Active measures would be undertaken to manipulate the water level and manage vegetation to optimise the wetlands as a waterfowl habitat;
- establishment of extensive tracts of pine on the cleared and semi-cleared land as a response to the State's requirement for increased softwood supplies. The layout and design of the pine forest would be done in accordance with accepted landscape planning principles. The size and shape of planting cells would respect existing landscape boun-

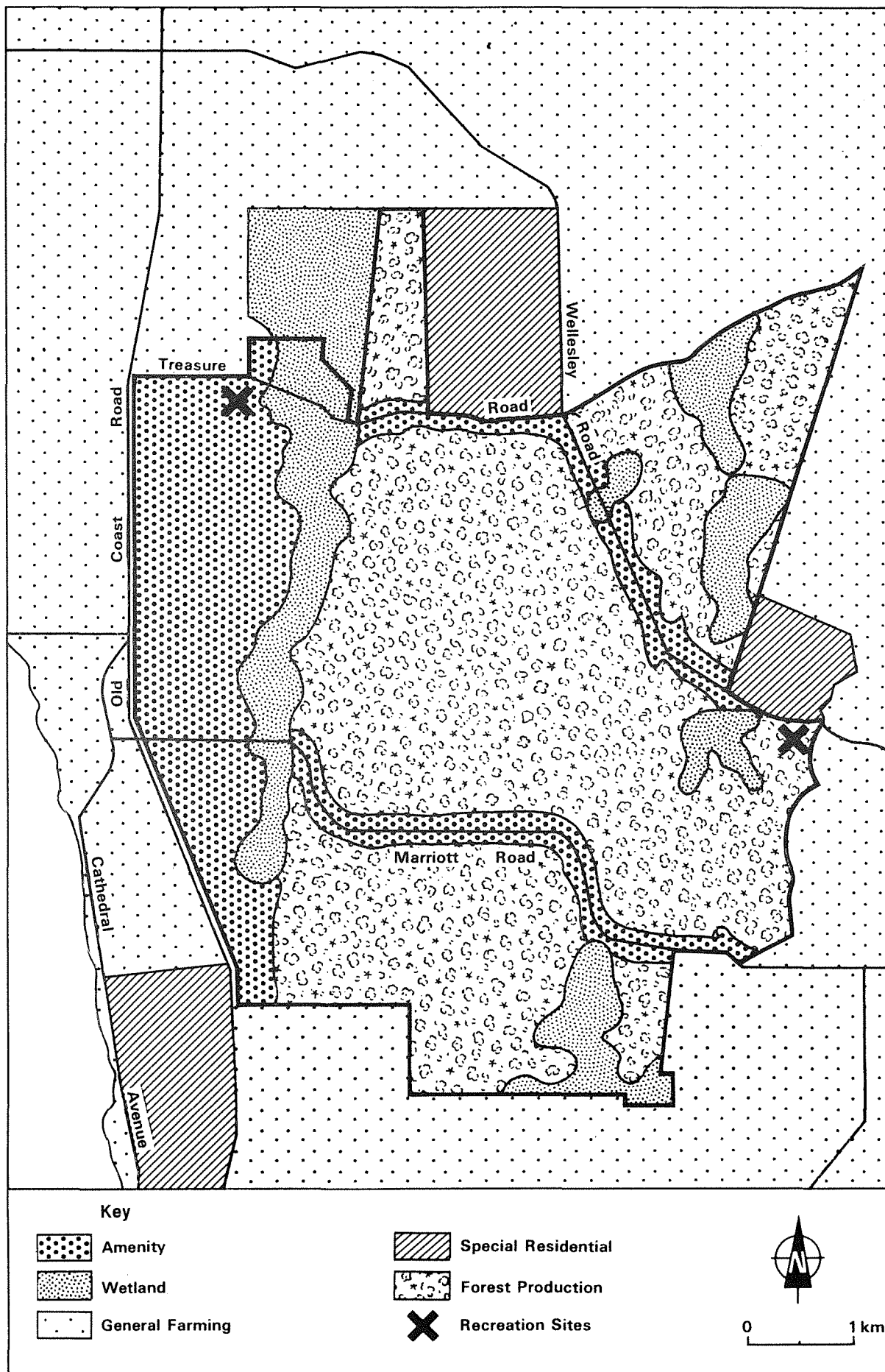


Figure E-1 — Conceptual Land Management Plan.

Source: Forests Department (1985).

daries and features such as drainage lines, pockets of remnant vegetation, etc. Pines would be planted over most of the area allocated to forest production, except where soil quality or other factors would prevent satisfactory growth. Land which already has good pasture would be managed for agro-forestry, with trees being widely spaced to allow for intermittent grazing during winter and spring;

- enhancement of amenity along road corridors through the establishment of indigenous species along the major public roads. Planting would be designed to complement and build upon existing groves of trees; and
- accommodation of existing land uses in the Kemerton area which are compatible with this plan. For example, the piggery and abattoir located on Marriott Road would not be affected by the broad scale management proposals in the Conceptual Plan. Likewise the existing rural retreat and farmlet developments near Kemerton would be accommodated in the plan.

The plan was prepared on the basis that it would proceed whether or not an aluminium smelter was established within the area. While the plan recognises that a smelter may be a potential land use, the management proposals are considered to be largely independent of and generally unaffected by a smelter, although the boundaries and extent of the proposed land uses are likely to be influenced (Forests Dept., 1985).

The total area encompassed by this Conceptual Plan has yet to be finalised. The boundary indicated in Figure E-1 is, therefore, indicative only at this stage. A final plan will be produced after it is known whether the smelter will proceed at this site.

3. EFFECTS OF THE PROPOSED SMELTER ON THE CONCEPTUAL PLAN

The Conceptual Land Management Plan indicates that, while land uses proposed are generally unaffected by the smelter proposal, their boundaries and extent are likely to be influenced.

The proposed aluminium smelter would affect the proposed land uses in many ways. A number of these are raised in the Assessment Report, and they are also mentioned here:

- the air emission from the smelter would require the selection of pine stock that shows resistance to both gaseous and particulate forms of fluoride and sulphur dioxide;
- as some indigenous flora species would be likely to be affected by these emissions, the land manager would need to undertake remedial activities to replace these with more tolerant species, resulting in a new vegetation pattern;
- a construction camp which would require several hectares is proposed in the ERMP to be located within the buffer area. This may alter the timetable for implementation of the Plan on that site;
- it is proposed by the proponent in the Supplement that construction materials would be obtained from outside the plant site. In particular, the high dune to the west of the plant site would be used to provide fill material. The amount of material required is unknown but could be substantial (Section 7.1.2.2). The Conceptual Plan identifies Forest Production as the priority land use for this dune;
- in addition to providing fill to the proponent, it is envisaged by Westrail that sand fill for the construction of the railway into the smelter would be obtained from within the buffer area. Up to 40,000 cubic metres will be required for this construction;
- this railway will require an easement through the Forest Production area. The extent of land used for this will depend on the orientation of the smelter, and whether the railway has a closed layout, such as the spur illustrated in the ERMP, or an open, circular layout. The latter would require more land but would be preferred for operational reasons by Westrail;
- while the piggery and abattoir are considered in the Conceptual Plan to be consistent with the Plan, the proponent has indicated to the Authority that these activities would not continue to operate unless the proponent agrees that they are consistent; and
- a further development associated with the smelter is the supply of electricity. Two major transmission lines, one from the north and the other from the south-east, will link the smelter to the SECWA's interconnected grid. A large substation complex would be established adjacent to the smelter, comprising 330 kV and 130 kV switch yards. These substations would require an area of approximately 6 hectares. Easements for the power lines would be required through the Forest Production area.

The pine plantations to be established in accordance with the Conceptual Plan would act as a fluoride sink. Pines, which would be selected to be relatively tolerant to fluoride, would be planted to maximise the uptake of fluoride in the buffer area. This vegetation, therefore, plays an important role in the successful management of air emission from the smelter. Loss of this vegetation through fire would represent a significant diminution of the effectiveness of the sink,

and could cause the air emissions to affect additional land (i.e. the fluoride isopleths could expand). In addition, burning of vegetation and leaf litter with elevated fluoride levels could result in the release of fluoride onto the soil and into the groundwater.

4. ADDITIONAL FACTORS

Other factors will also have an effect. Some of these, such as poor soil conditions and wetlands, have been mentioned in the Conceptual Plan, but several others are also raised here:

- a potentially significant heavy mineral deposit has been defined in the central portion of the Kemerton area. The deposit, containing approximately 1 million tonnes of heavy minerals, is located on the western side of the major dune to the east of Mialla Lagoon. The Conceptual Plan, which delineates Forest Production as the proposed use of this area, would require modification if mining of the deposit takes place;
- several plants with restricted distributions have been located in the south-east portion of the Kemerton area. These are *Acacia flagelliformis*, *Cartonema philydroides* and *Villarsia violifolia*. In addition, *Pultenaea skinneri*, a gazetted rare species, has been collected in the same area. Protection of these and any other rare or restricted flora will necessitate additional conservation related priority areas;
- the Kemerton Area is currently zoned for "General Farming" in the Shire of Harvey's Town Planning Scheme (TPS) No. 10. The underlying planning policy for this zone is:

"Council intends to encourage these areas to continue to be used for viable large scale farming activity. Some limited tourist and recreational activity may be permitted where the effect of such development can be contained."

In this zone, "Forestry" (defined as the cultivation, management and felling of trees for commercial purposes) is not permitted unless special approval is given by the Shire Council, following a period of advertisement.

Whether the proposals outlined in the Conceptual Plan for the Kemerton area are required to comply with the provisions of the Shire's TPS No. 10 will depend on the tenure of the area;

- the Conceptual Plan only partially accommodates the System 6 recommendations that affect portions of the buffer area around the Kemerton site. The Plan includes Mialla Lagoon in a wetland conservation priority area, but does not contain proposals for the Wellesley River. Additionally, the Plan does not address its implications in terms of the regional land planning and management issues raised in the System 6 recommendations. Because it is a State Government initiative, the Conceptual Plan would provide a sound means of preserving the intent of the System 6 recommendations pending action to implement them. It is necessary, therefore, that the Plan give due consideration to these recommendations; and
- a substantial forest production area would have an effect on groundwater levels beneath and adjoining the area. In the case of plantations of fast growing trees, such as the pine species proposed in the Conceptual Plan these effects may be significant, particularly in the case of adjacent wetland areas, due to the high water demand of the trees.

RECOMMENDATION 25:

The EPA recommends that the Department of Conservation and Land Management monitors groundwater and wetland water levels both as a component towards on-going management of the wetlands, and to assist in determining any long-term effects that the proposed pine plantation might have on the water regime of the Kemerton area.

5. CONCLUSION

The establishment of an adequately managed buffer area around the proposed aluminium smelter must be considered as an integral and important component in any smelter development. If the management of this area can also provide significant benefit to the community, in terms of offering a range of land uses and facilities that are attractive and desirable, the plan presents possibilities that might appeal to the community.

The Conceptual Land Management Plan does not explicitly include a scenario which considers the implications of the construction and operational requirements of the aluminium smelter and associated developments. These would influence proposed land use to some extent at least, and some would require a change in land use. The Government has chosen to accept responsibility for the management of the impact of the smelter in the area that would be affected most. Adequate and proper planning must be based on a process of identification of best uses and constraints and the development of a management plan that takes these into account.

RECOMMENDATION 26:

The EPA recommends that, in view of the known occurrence of rare and endangered species, a study be undertaken by the Department of Conservation and Land Management to identify those aspects of the floral communities in the buffer zone that have conservation value and may need appropriate management. This study should be completed prior to development in the Kemerton area.

RECOMMENDATION 27:

The EPA recommends that a detailed land management plan for the Kemerton area should be prepared and implemented as soon as possible. The provisions of this plan should be compatible with the operation of a smelter within the area, and should include an appropriate fire management plan.

In addition the Authority notes the establishment by the Government of a working group to consider the recreational potential of the Kemerton and nearby areas.

In order that the operations of the proposed smelter and the management of the Kemerton area are co-ordinated and are supportive there is the need for clear definition of responsibility for the management of the area and the mechanisms through which possible conflicts between the proponent and the Department of Conservation and Land Management can be resolved. In this respect, the objectives of the future management plan are relevant.

REFERENCE:

FORESTS DEPARTMENT (1985) Conceptual Land Management Plan — Kemerton Area.

APPENDIX F BRIEF DESCRIPTION OF SITES

APPENDIX F

BRIEF DESCRIPTION OF SITES

(Source : Notice of Intent and ERMP)

SITE A, LAKE CLIFTON EAST

This area is mainly wooded with some clearing facilitating small-scale beef cattle grazing. Harvey Estuary and the Harvey Estuary Nature Reserve are directly north and east of the property. Yalgorup National Park extends parallel to the property directly to the west, with Lake Clifton approaching to within 300 metres at the closest point. Areas on and adjacent to the land are proposed for Special Rural development (Mandurah and Waroona Policy Plan No. 2), with an area abutting the north-east zoned for recreation.

Existing residential settlement is limited, with most homes site along either Harvey Estuary or Lake Clifton, to take advantage of both the scenic qualities and recreational potential they offer.

SITE B, LAKE PRESTON EAST

The land of interest near Lake Preston consists of low-lying, semi-cleared land, currently supporting limited dryland beef and sheep grazing activities. Nature reserves are located directly to the south and east, and a softwood plantation abuts to the north-west.

The site is close to areas of open space including Peel Inlet, Harvey Inlet, Lakes McLarty and Mealup, Yalgorup National Park and the Lake Clifton Management Priority Area (MPA), but the proponent believed that a smelter could be located without physically intruding on any of these areas.

SITE C, BINNINGUP NORTH

The Binningup site is divided approximately evenly between the broad coastal Spearwood Dune System on the west and the generally flat Yoongarillup Plain to the east (McArthur and Bartle, 1980). Seasonal and permanent swamps run north-south approximately centrally through the site, effectively separating the undeveloped dunes and the residential settlements of Myalup and Binningup to the west from the agricultural properties to the east.

The Yoongarillup Plain in this locality has been developed for intensive agriculture (orchards directly north of Binningup Road) and for dryland grazing. Only two relatively undisturbed stands of woodland remain.

Binningup township is undergoing considerable growth, and substantial residences have been established in an attractive beachside setting. Myalup Beach is less developed, but still supports non-permanently occupied residences in pleasant surroundings. Many of the homes in both centres are owned by residents of neighbouring areas, who intend to move to the coast on their retirement.

SITE D, KEMERTON

The Kemerton site and surrounds include both cleared and partially cleared grazing land of low biological value and some largely uncleared woodland and wetlands of moderate biological value in the regional context. The likely plant location would not encroach on the more significant biological areas, and could be adequately screened. Other factors such as potential environmental impacts and socio-economic factors were considered to be reasonable at this site.

SITES E AND F, BUNBURY EAST

Much of the land close to Bunbury and proposed for industrial development has many characteristics which would suit it for the establishment of an aluminium smelter. However a large buffer zone would be necessary because of proposed adjacent residential and park and recreation areas.

The proponent believed that there is no land zoned industrial which would be available for a smelter, without imposing unacceptable impacts on adjacent activities or constraining development currently proposed for the area.

SITE G, MINNINUP

Minninup is a coastal area south of Bunbury consisting of relatively undisturbed areas of native vegetation backing a broad coastal dune system. The Bunbury Region Plan identifies a significant portion of the forested area as being suited to development as State Forest. Wetland areas in the depressions of the dunal system are regarded as being worthy of consideration for conservation and reserves.

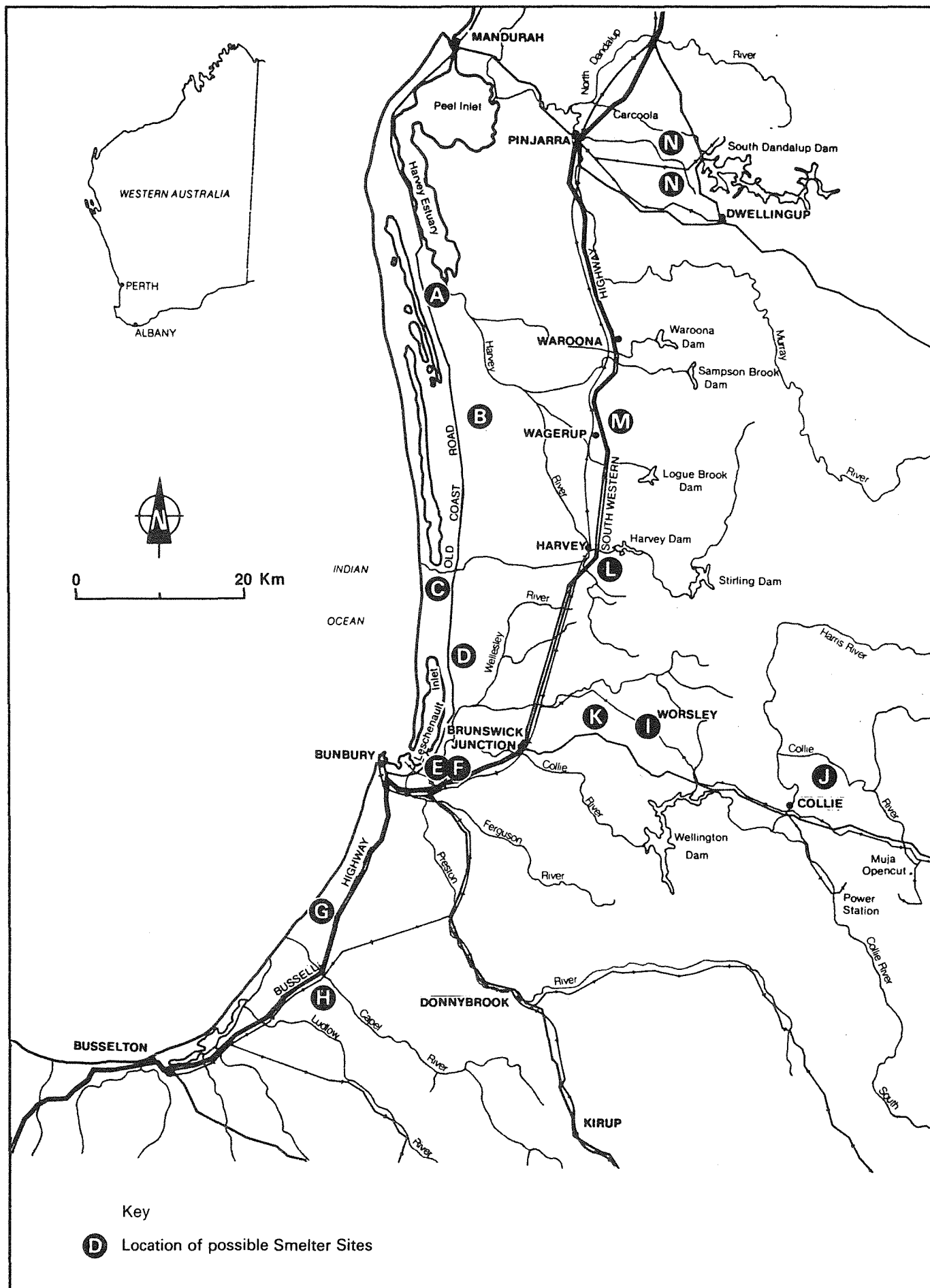


Figure F-1 — Locations of Alternative Smelter Sites Considered by the Proponent.

Source: ERMP

The area is currently being marketed for acreage development, both for permanent and holiday residences. A significant holding to the north-east has been identified as being suited to zoning as special rural, although it is understood that allowance has been made so that it can at a later date be further subdivided into normal residential sites.

SITE H, CAPEL SOUTH

Large areas surrounding Capel have and are being mined for heavy mineral sands. Considerable worked out zones remain, generally in the form of bunded tailings dams left to dry prior to rehabilitation. Biologically, the area is suitable for the development of an aluminium smelter, with the majority of the native vegetation already altered by mining. However foundation conditions are considered to be poor because of the disturbed ground.

SITE I, WORSLEY SIDING

The site proposed for the smelter is in jarrah forest, adjacent to an existing area of cleared land. The forest has been logged and burned and is crossed by transport corridors and service easements.

The proponent considered that the biological significance of the area is largely in its inherent quality and potential for regeneration, representing as it does a portion of the relatively limited area of remaining high rainfall jarrah-marri forest. In its current condition, the area has only moderate conservation value. This rating would be higher if the long-term security of the area was assured.

Specific impacts of fluoride on jarrah forest nutrition, native fauna, forest diseases and insects are not understood. Other factors such as infrastructure and socio-economic factors were considered to be reasonable.

SITE J, COLLIE EAST

The Collie East site is set amongst private freehold land lining the eastern arm of the Collie River. The area is partially cleared, and falls within the Wellington Dam catchment. State Forest areas to the north and east, and the proposed Harris River Dam to the north-west, are both considered to be beyond the likely zone of influence of a smelter located at this site.

On environmental grounds, the Collie East site rates similarly to Site I, Worsley Siding, with perhaps the potential for slightly less impact on the forest environment in the former case given the greater extent of local clearing. The Collie option is more visually prominent, and would be quite obvious from the town. Potential air emission impacts at Collie would need to take into account ambient concentrations of other pollutants emitted from existing and planned power stations.

Social impacts on Collie from population growth resulting from a smelter built at this location are expected to be considerable.

SITE K, ROELANDS EAST

Several sites in this general area were examined by the proponent. In each case, the areas were sown with improved pasture, and sheep grazing was the predominant activity. Near the edge of the escarpment, an aluminium smelter would be very obvious from the coastal plain. As this was considered to be unacceptable, only those areas eastwards from approximately the 8 km mark were considered further.

Potential air emission impacts would relate to agricultural activities rather than forestry. Socio-economic and infrastructure factors would be the same as for Site I and were considered to be reasonable.

SITE L, HARVEY SOUTH

An area of cleared farmland 4 km south-east of Harvey was considered. Land uses in the area are beef cattle and sheep grazing with dairying activities to the west and some citrus growing. The site is severely constrained topographically and would require 'economically unrealistic earthworks' (Helleman, 1985) to provide a level platform. Modelling of air emissions would also be very difficult.

SITE M, WAGERUP

The alumina refinery buffer area at Wagerup has level areas within its buffer that would be physically suitable for a smelter. Landscaping and screening already undertaken by the land's owner, Alcoa of Australia Ltd, could reduce the usual impact of a smelter.

With the establishment of the smelter following on so close to the alumina refinery start-up, the proponent concluded that significant social impacts could affect nearby communities.

SITES N, PINJARRA

Two potential sites were identified on land that forms part of the buffer to Alcoa's Pinjarra alumina refinery. The land has largely been cleared.

Some engineering problems might arise from the presence of local groundwater springs. Most infrastructure requirements are in close proximity to the sites, except for a port facility. Some social and community infrastructure at Pinjarra and Mandurah may be placed under pressure as a consequence of a smelter development. In addition, the close proximity of continuous process industries might cause industrial relations problems.

REFERENCE:

McARTHUR, W.M. & BARTLE, G.A. (1980) Soils and Land Use Planning in the Mandurah-Bunbury Coastal Zone, Western Australia. CSIRO Land Resources Management Series No. 6.

APPENDIX G

LIST OF SUBMISSIONS ON THE ERMP

FROM THE PUBLIC AND FROM COMMUNITY ORGANISATIONS

APPENDIX G

LIST OF SUBMISSIONS ON THE ERMP FROM THE PUBLIC AND FROM COMMUNITY ORGANISATIONS

The names and addresses of the authors of thirty-six submissions are listed. Thirty-four of these are summarised in Section 6.1 of the Assessment Report, and the two submissions from the Shire of Harvey are briefly summarised in Section 6.2.

The order of names and addresses presented in this Appendix bears no relation to the order of submission in Table 8 of Section 6.1 of this Assessment Report.

NAME	ADDRESS
Associated Minerals Consolidated Ltd	NEDLANDS WA 6009
Conservation Council of SA	ADELAIDE SA 5000
Mr G V L Bicknell	AUSTRALIND WA 6230
Bunbury Voluntary Community Group (Inc.)	BUNBURY WA 6230
Terry Burke JP MLA	
Petition to Legislative Assembly	PERTH WA 6000
Mr Laurie Capill	PERTH WA 6000
City of Bunbury	BUNBURY WA 6230
CSIRO Groundwater Research	WEMBLEY WA 6014
Peter P and K S Eckersley	LESCENAULT WA 6230
Jill and Robert Greeve	AUSTRALIND WA 6230
E P and B R James	LESCENAULT WA 6230
Kinhill Stearns	MELBOURNE VIC 3000
Mrs L M Levingston	AUSTRALIND WA 6230
Peter McLean	COLLIE WA 6225
Ian W Offer	BRUNSWICK JUNCTION WA 6224
Leslie E Oliver	AUSTRALIND WA 6230 (2 submissions)
S G Palmer	
'Remlap Stud'	NEDLANDS WA 6009
A R and S E Pannell	
Brunswick Junction	BRUNSWICK JUNCTION WA 6224
David Partridge (and family)	BRUNSWICK JUNCTION WA 6224
B W Ridley	BRUNSWICK JUNCTION WA 6224
M L and J F Rodwell	BRUNSWICK JUNCTION WA 6224
Keith D Rose	
K D Rose and Co.	BUREKUP WA 6227
Neil Ross	BRUNSWICK JUNCTION WA 6224
Mrs P M J Ross	BRUNSWICK JUNCTION WA 6224
Judyth Salom	BRUNSWICK JUNCTION WA 6224
Terence L Salom	BRUNSWICK JUNCTION WA 6224
Denese M Shepherdson	BRUNSWICK JUNCTION WA 6224
Shire of Harvey	HARVEY WA 6220 (2 submissions)
Martin F and Jennifer A Short	WELLESLEY WA 6230
SMELT	BRUNSWICK JUNCTION WA 6224
The Tree Society	CLAREMONT WA 6010
Arthur S Weston	ST JAMES WA 6102
H Williams	AUSTRALIND WA 6230

APPENDIX H

THE RELATIONSHIP BETWEEN FLUORIDE

IN AIR AND FLUORIDE IN FORAGE

APPENDIX H

THE RELATIONSHIP BETWEEN FLUORIDE IN AIR AND FLUORIDE IN FORAGE

To protect the health of domestic animals grazing around sources of fluoride, standards have been promulgated in many countries of the world. Dairy cattle are recognised as the most sensitive domestic animals to fluoride and the standards have been developed to protect them on the assumption that in doing so, they would also protect all other domestic animals. The standards are not designed to protect dairy cattle from all effects of fluoride, but only to protect their economic value. The standards have been developed for fluoride concentrations in unwashed pasture as these usually have a high correlation with the total amount of fluoride ingested. Feed supplements, and other potential fluoride sources in the diet should also be taken into account. Standards based on tissue fluoride concentrations, effects on animals, or atmospheric fluoride concentrations, were avoided for many reasons including biological variability, cost, insufficient information and sampling problems. The standards require that the fluoride concentration of monthly samples of unwashed pastures should not exceed any of the following:

- 80 $\mu\text{gF/g}$ for more than one month per year;
- 60 $\mu\text{gF/g}$ for more than two months per year;
- 40 $\mu\text{gF/g}$ as an annual mean.

These standards are not universally accepted as, for example Maryland (USA) has adopted 35 $\mu\text{gF/g}$ instead of 40 $\mu\text{gF/g}$ as an annual mean, and there is considerable debate in the literature based on circumstances at Cornwall Island on the US/Canadian border, concerning whether these standards provide adequate protection for dairy cattle. However, the large majority of standards for fluoride in pastures are based on these values.

There is a requirement for the predictions of ambient fluoride concentrations, based on dispersion models, to be capable of being related to potential effects of fluoride. In the case of domestic animals this would require the ability to equate an ambient fluoride concentration to fluoride concentrations in unwashed pasture samples.

- The results obtained by Israel (1974a, b) show that a fluoride concentration in unwashed grass samples of 40 $\mu\text{g/g}$ is correlated with an annual average concentration of gaseous fluoride in air of 0.315 $\mu\text{g/m}^3$.
- Calculations based on the data of Alary et al. (1981), assuming a windspeed of 3.6 metres per second, show that a fluoride concentration of 40 $\mu\text{g/g}$ in unwashed grass samples is correlated with an annual average concentration of gaseous fluoride in air of 0.31 $\mu\text{g/m}^3$.
- Less *et al.* (1974) estimated that an atmospheric gaseous fluoride concentration (as HF) of 1 $\mu\text{g/m}^3$ generally leads to a long-term accumulation of about 100 $\mu\text{g/g}$ of fluoride in forage.

CONCLUSION

An annual mean concentration of 0.3 $\mu\text{g/m}^3$ for gaseous fluoride may be expected to be associated with unwashed pasture fluoride concentrations of about 40 $\mu\text{gF/g}$ dry weight as an annual mean of monthly values. This relationship is variable and depends upon particulate fluoride concentrations, windspeed, rainfall, other climatic factors and soil water availability.

REFERENCES

- ALARY J., BOURBON, P., Balsa, C., BONTE, J. AND BONTE, C. (1981) A field study of the validity of static paper sampling in fluoride pollution surveys. *The Science of the Total Environment*. 20, 11-18.
- ISRAEL, G.W. (1974a) Evaluation and comparison of three atmospheric fluoride monitors under field conditions. *Atmospheric Environment*. 8, 159-166.
- ISRAEL, G.W. (1974b) A field study of the correlation of static lime paper sampler with forage and cattle urine. *Atmospheric Environment*. 8, 167-181.
- LESS, L.N., MCGREGOR, A., JONES, L.H.P., GOWLING, D.W. & LEAFE, E.L. (1975) Fluoride uptake by grass from aluminium smelter fume. *International Journal of Environmental Studies*. 7, 153-160.

APPENDIX I

THE BIOLOGICAL EFFECTS OF FLUORIDE

APPENDIX I

THE BIOLOGICAL EFFECTS OF FLUORIDE

This Appendix is written for interested members of the public and contains a number of judgements based on the results of a large number of scientific studies. Individuals who may wish to investigate the issues and studies further are referred to Suttie (1977), Weinstein (1977), Smith and Hodge (1979), US EPA (1980) and WHO (1984).

Consideration is given to the effects of exposure to relatively small amounts of fluoride over long periods of time (chronic exposures). These effects are considered to be the most realistic based upon the characteristics of fluoride emissions from modern industrial sources. The effects of exposure to very high concentrations of fluoride, which often result in an almost immediate response (acute exposures), are not considered likely. However, interested individuals are referred to the above publications.

Fluoride is widely distributed in the natural environment, ranking 13th among the elements in order of abundance in the earth's crust. It occurs in rocks, soils, groundwater, surface waters, air, plants and animals. Fluoride is also an important industrial emission which is released when fluoride-containing materials are heated to high temperatures. The main industrial processes involved are coal-fired power stations, aluminium smelters, steel plants, phosphate fertiliser works, brick, tile and glass works, oil refineries and some ore-refining and chemical plants.

Fluoride may be released in a gaseous form or particulate (dust) form. The fluoride-containing dusts released from a short chimney or the roof of a building such as an aluminium smelter potroom are deposited close to the source, but gases may be transported greater distances. Fluoride may be readily transported in the environment and a schematic diagram (Figure I-1) illustrates some of the transport pathways.

1. EFFECTS ON PLANTS

Fluoride is one of the most important air pollutants. In terms of its effects on plants it is regarded as the second most important air pollutant in Europe (Knabe, 1978) and the fourth in the USA (Heck, 1982). It is the most toxic to plants of the common air pollutants, causing injury at concentrations in air about 100 times lower than the rest (e.g. ozone, sulphur dioxide and nitrogen oxides).

Fluoride-containing dusts may be deposited on leaf surfaces but they only slowly enter the plant, particularly under dry conditions or when the dust is relatively insoluble in water. However gaseous fluorides such as hydrogen fluorides are very reactive with plant surfaces particularly when moist, and may be deposited on the leaf surface and slowly enter the leaf, or may enter the leaf directly through the breathing pores (stomata). Once inside the leaf, fluoride moves to the tips or perimeter of the leaf where it may accumulate. Fluoride may be lost from leaves by weathering, volatilisation* or growth dilution. Under wet conditions fluoride concentrations in pastures may be halved in 24 hours (Davison and Blakemore, 1979). If sufficient fluoride accumulates it may influence the biochemical functioning of the leaf, cause a yellowing (chlorosis), or kill (necrosis*) parts of the leaf. If sufficient leaf area is killed, leaf drop may occur and if large areas of plant are injured, dieback or even plant death is possible. Fluoride may also cause abnormal fruit development. However, the symptoms of fluoride injury are similar to a number of other plant diseases including some nutrient deficiencies and visible symptoms alone are not diagnostic of fluoride injury (Lacasse and Treshow, 1978).

Fluoride is not usually very mobile in plants. Plants accumulate relatively little fluoride in above-ground parts from soils, although saline soils are an exception to this. Even when leaf fluoride concentrations are high, relatively little fluoride can be found in seeds flowers or fruit. When garden vegetables are exposed to airborne fluoride, leafy vegetables with open leaf arrangements (e.g. spinach) accumulate most fluoride, but plants with closed leaf arrangements (e.g. cabbage, lettuce), flowers (e.g. cauliflower, broccoli), fruit (e.g. peaches, tomato) and root crops (potato, onion) have very little fluoride in the edible parts. Food preparation further reduces this by the practice of discarding the outer leaves which contain most of the fluoride, and washing or peeling which removes fluoride deposited on surfaces.

Plants vary considerably in their sensitivity to fluorides. Some species may show injury to leaves after exposure to concentrations of fluoride in air as low as 0.2 micrograms of fluoride per cubic metre of air ($\mu\text{g}/\text{m}^3$) over several months (Sidhu, 1980; Murray, 1984). Other species may be exposed to up to 1000 times this amount without injury (Weinstein, 1977). The most sensitive species to leaf injury are grapevines, young conifer foliage, gladiolus and some cultivars of sorghum (Table I-1). Some groups of eucalypts such as the bloodwoods (e.g. *marri*) are sensitive to fluoride injury but others such as ironbarks are more resistant. Jarrah may be intermediate in fluoride resistance. In some species injury to fruit may occur without leaf injury. Peach fruit is very sensitive to fluoride but peach leaves are about ten times more resistant.

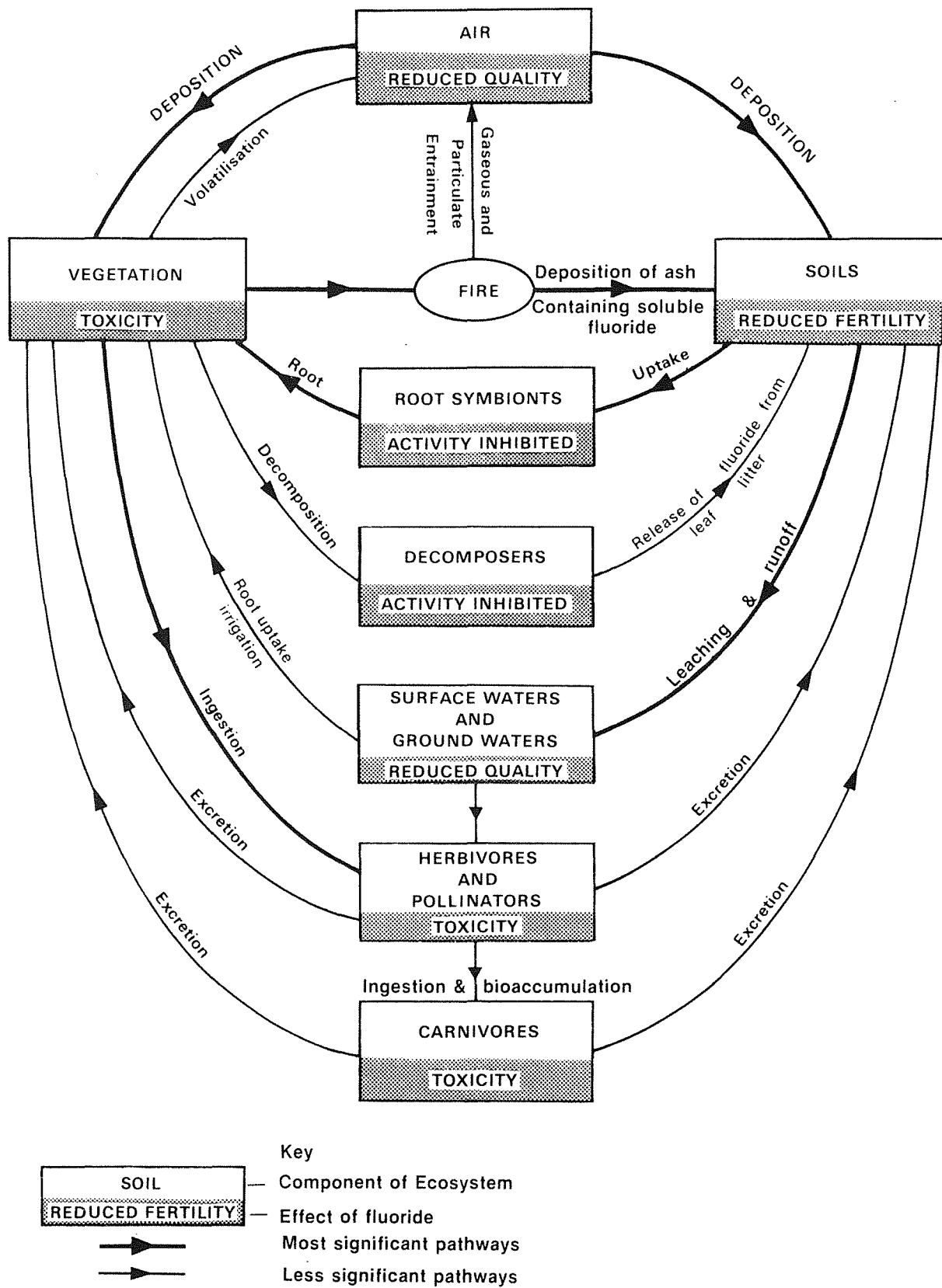


Figure I-1 — Major Pathways for Fluoride in Ecosystems.

Table I.1 Relative Sensitivity of some Common Plant Species to Atmospheric Fluoride

	Fluoride Sensitivity		
	Sensitive	Intermediate	Resistant
Apple		*	
Apricot		*	
Bean			*
Cabbage			*
Capsicum		*	
Carrot			*
Cauliflower			*
Celery			*
Cherry		*	
Chrysanthemum			*
Clover (White)		*	
Corn (Sweet)#	*		
Cucumber			*
Eggplant			*
Eucalyptus — marri	*		
— jarrah		*	
Gladiolus	*		
Grapevine	*		
Grapefruit		*	
Lemon		*	
Lucerne			*
Marigold			*
Orange		*	
Pea (garden)			*
Peach (foliage)		*	
Peach (fruit)	*		
Pear			*
Pine # (young needles)	*		
(old needles)			*
Plum #	*		
Potato			*
Potato (sweet)		*	
Rose		*	
Ryegrass			*
Sorghum #	*		
Strawberry			*
Tomato		*	
Wheat		*	

Applies to some varieties or species only.

Reductions in growth or yield may be independent of any visible signs of fluoride injury. Leaves may be injured without affecting growth or yield and *vice versa* (Davison, 1982).

Fluoride is also unique among the common gaseous air pollutants as it may accumulate in vegetation and cause injury to animals when this contaminated vegetation is consumed. In pastures, accumulation of excessive fluoride is of greater relevance than leaf injury, because accumulation of fluoride concentrations which may cause injury to sensitive animals such as dairy cattle usually occurs long before foliar injury is obvious in pasture species. Soils are not normally contaminated to any significant extent by airborne fluoride emissions, as deposition rates are low in comparison with normal background levels and fluoride is readily bound by factors which are present in almost all agricultural soils (Murray, 1984).

Fluoride accumulation in pastures is enhanced by:

- greater concentration of pollutant;
- greater duration of exposure;
- open sward* structure;
- low leaf turnover rate; and
- lack of rainfall.

Fluoride concentrations in pastures may also be increased by the use of phosphate fertilisers which contain up to several per cent of fluoride.

2. CHRONIC EFFECTS ON ANIMALS

Fluoride may be consumed by animals by a number of means. Fluoride may be present in food, water, mineral supplements, drugs, soils or sediments ingested by animals, or air which is inhaled. The inhalation of airborne fluoride and skin absorption account for an extremely small part of the total fluoride ingested around major industrial sources of fluoride, because concentrations of fluoride in air are so much lower than concentrations in vegetation exposed to fluoride. The main sources of fluoride for most animals are fluoride-contaminated food and water, and feed supplements which have not been properly defluorinated (US EPA, 1980).

Animals show a wide range of resistance to fluorides, however much less is known about wildlife than domestic animals. Most studies have been conducted on dairy heifers, the most sensitive of the domestic animals to fluoride. Studies have enabled a list of dietary fluoride tolerances of domestic animals to be compiled (Table I-2).

A proportion of the fluoride ingested by animals is eliminated in faeces, and the proportion depends on the chemical and physical form of the fluoride. Some of the fluoride enters the blood and is later excreted as urine. However a small proportion of the fluoride is bound in hard tissues such as bones and teeth. Only very small concentrations of fluoride occur in milk or the soft tissues such as muscle.

Table I.2 Dietary fluoride tolerances for domestic animals (a)

Animal	Performance (b) (mg/kg)	Pathology (c) (mg/kg)
Beef or dairy heifers	40	30
Mature beef or dairy cattle (d)	50	40
Finishing cattle	100	NA (d)
Feeder lambs	150	ID
Breeding ewes	60	ID
Horses	60	40
Finishing pigs	150	NA
Breeding sows	150	100
Growing or broiler chickens	300	ID
Laying or breeding hens	400	ID
Turkeys (e)	400	ID
Growing dogs	100	50

(a) The values are presented as mg/kg F in dietary dry matter and assume the ingestion of a soluble fluoride, such as NaF. When the fluoride in the ration is present as some form of defluorinated rock phosphate, these tolerances may be increased by 50%.

(b) Levels that, on the basis of published data for this species, could be fed without clinical interference with normal performance.

(c) At this level of fluoride intake, pathologic changes occur. The effects of these changes on performance are not fully known.

(d) Cattle first exposed to this level at 3 years of age or older.

(e) This level has been shown to be safe for growing female turkeys. Very limited data suggest that the tolerance for growing male turkeys may be lower.

NA = Not applicable

ID = Insufficient data

Source : US National Academy of Sciences (1974)

The symptoms of exposure of domestic animals to excessive fluoride for extended periods of time depend on the amount and type of fluoride, the period of ingestion, the age, nutrition and stress level of the animals, and the individual biological response. If domestic animals are exposed to fluoride during the period of tooth development, chalkiness, mottling or thin enamel may result, and affected teeth may be subject to more rapid wear. Skeletal changes may occur and instead of bones being hard and smooth they can become heavy, porous, rough or chalky white. Outgrowth of bones may occur and leg bone tendons may calcify. The animal may be intermittently lame or stiff. When these more severe symptoms occur the animal may eat less and performance may decline.

In order to protect grazing animals, standards have been promulgated based on limiting the fluoride content of the pastures on which the animals graze. These standards are designed to protect dairy cattle on the basis that these are the most sensitive domestic animals, and standards which protect them will also protect all other domestic animals.

The most commonly used standards, used by many countries throughout the world (IPAI, 1981), have been set at a level which would prevent economic damage to cattle, but not to ensure that no signs of fluoride ingestion are observed (Suttie, 1977). These standards propose that fluoride emissions should be regulated so that the fluoride concentration of the forage the animal would eat does not exceed:

- 80 $\mu\text{g/g}$ for more than one month;
- 60 $\mu\text{g/g}$ for more than two consecutive months; or
- 40 $\mu\text{g/g}$ for the yearly average of monthly results.

Some recent studies have suggested that these standards may not provide a sufficient level of protection for dairy cattle under all circumstances. Some authorities (e.g. the State Pollution Control Commission in NSW) use 35 $\mu\text{gF/g}$ as the maximum annual average.

Properties subject to excessive fluoride exposure may be assisted by appropriate management techniques. These may involve:

- suitable pasture management procedures;
- stock and pasture rotation;
- the use of supplementary feed containing low fluoride concentrations;
- the avoidance of dietary supplements, drugs and water containing significant amounts of fluoride; and
- responses to the results of monitoring programmes, which should include fluoride analysis of food and water and regular veterinary inspection.

Pasture management aims to reduce the fluoride concentration by:

- removing fluoride adhering to leaf surfaces by spray irrigation;
- growth dilution of fluoride by encouraging pasture growth;
- avoiding the use of fluoride-containing fertilisers and chemicals; and
- in some cases slashing to remove fluoride accumulated at the apex of pasture grasses. If fertilisers are used, fertilisers containing high fluoride concentrations should be replaced by others containing lower concentrations where possible.

Elevated fluoride concentrations have been measured in many species of wild animals but very little information is available on effects. Reductions in populations of wild birds have been reported around old aluminium smelters in Czechoslovakia (Newman, 1979). Studies of aquatic animals have shown that many environmental factors such as temperature and salinity influence the responses of fish to fluorides. Crustaceans appear to be more resistant to fluoride than fish. Although much more work is required, studies suggest that fluoride concentrations of less than 1.5 mg/L in water have no deleterious effects on aquatic fauna (US EPA, 1980).

Some insects appear to be relatively sensitive to fluoride and honey bees have been killed around old aluminium smelters. Fluoride may reduce growth and reproduction in invertebrates (US EPA, 1980). Effects on ecological relationships involving insects are discussed in the ecosystems section of this Appendix.

3. CHRONIC EFFECTS ON HUMANS

Fluoride may have beneficial or toxic effects on humans depending, among other things, on the quantity of fluoride ingested. Beneficial effects may result from the ingestion of a few milligrams of fluoride per day resulting in a reduction in dental caries (WHO, 1984). Fluoride is added to many public water supplies for this reason. High doses of fluoride may result in detrimental effects. The main sources of fluoride for humans is food, beverages, drugs and dentifrices*. Very small quantities of fluoride are inhaled by people living near fluoride emission sources. The average respiration rate of a person is about 20 cubic metres (m^3) per day (WHO, 1984). Therefore, for a resident living in an area with 0.3 ($\mu\text{gF}/\text{m}^3$) in air and if all of the fluoride was retained, the daily intake would be 6 μg of fluoride. This is as much fluoride as contained in 6 millilitres (about one hundredth of a pint) of town water when the town water supply is fluoridated at the normal rate (1mg/L). Occupational exposure may result in much higher rates of fluoride intake. Assuming a total respiration rate of 10 m^3 during a working day, the daily amount of fluoride inhaled could be as high as 10 — 25 mg, when the air concentration is at the most frequent exposure limits of 1 — 2.5 mg/ m^3 (ILO, 1980). Depending on hygiene conditions, dust contamination in the industrial setting could also add to the oral intake of fluoride (WHO, 1984).

Strict occupation hygiene measures ensure that fluoride concentrations in potrooms of modern aluminium smelters remain within acceptable limits. Monitoring of fluoride in the urine of potroom

workers indicates the margin of safety, ensuring that occupational hygiene is maintained at all times.

Fluoride concentrations are high in some foods, especially canned fish and tea. The ingestion of vegetables grown around fluoride emission sources has been estimated to increase fluoride intake of local residents by about 1.7% when the water supply is not fluoridated or 1% when the water supply is fluoridated (WHO, 1984).

Rainwater collected from roof areas for drinking water around fluoride emission sources may contain increased fluoride concentrations. Normally rainwater contains very low concentrations of fluoride in rural areas except where the rocks and soils have high natural fluoride concentrations. The fluoride concentration which ultimately may be measured in tap water depends on many factors such as the rate of fluoride deposition on the roof, and cannot be predicted with any certainty, but monitoring may be used to indicate whether unacceptable levels are being approached and other supplies may be arranged.

4. CHRONIC EFFECTS ON ECOSYSTEMS

4.1 AGRICULTURAL ECOSYSTEMS

The effects of fluoride on agricultural ecosystems are better known and understood than on natural ecosystems because the former are usually less complex than natural ecosystems and more studies have examined agricultural ecosystems. The effects of fluoride in agricultural ecosystems are determined by:

- factors relating to fluoride exposure such as the chemical and physical form of the fluoride, the concentration, duration of exposure and how exposed the ecosystem is, i.e. whether it is physically shielded; and
- factors relating to the response of the ecosystem, such as the sensitivity of the ecosystem components or processes during the period of exposure.

In the case of grazing areas, forage species accumulate a level of fluoride which causes damage to sensitive grazing animals such as dairy cattle, before any injury is visible to the pasture, although sensitive trees such as some conifers and marri, and some garden plants such as grapevines and gladiolus, would probably show symptoms of fluoride injury. However the same exposure conditions do not necessarily have the same response. Pastures with rapid growth do not accumulate fluoride concentrations as high as pastures with no growth, such as dryland pastures during summer. Cropping areas subject to frequent cutting such as lucerne, do not accumulate as much fluoride as crops which are harvested once, such as sorghum. Forage crops which are spray irrigated with water with low fluoride concentrations do not accumulate as much fluoride as trickle irrigated crops of pastures because fluoride is washed off the leaf surface by the irrigation water.

The harvested parts of root, grain and fruit crops do not accumulate fluoride to a significant extent as most fluoride is taken up by leaves and remains there, so, providing fluoride does not otherwise influence yield or quality, it has no effect on these crops.

4.2 FOREST PLANTATIONS

Forestry areas are subject to management which reduces the impacts of fluoride. When trees are being planted in an area subject to fluoride input, the genetic stocks of trees may be selected to ensure that they are productive at the concentrations expected, in the same way that trees to be planted in an area subject to other stresses (e.g. low nutrients, high salinity) would be selected, and managed to minimise that stress.

In established forests the impact of fluoride can be significant when concentrations are high. Economic damage has resulted from the effects of fluoride on sensitive tree plantations in some areas of the world when major emission sources have been constructed in very close proximity to these forests.

4.3 MARINE ECOSYSTEMS

Natural areas are often more complex and the effects of fluoride in these environments are less well understood. Liquid effluents containing fluoride are pumped into marine ecosystems in many parts of the world. Fluoride may accumulate in the water, flora, fauna and sediments. Some aquatic organisms are sensitive to fluorides, depending on the species and acclimatisation. Crustaceans such as crabs and prawns are tolerant of high fluoride levels in sea water. High fluoride concentrations may accumulate in edible tissues of crabs during exposure, although these quickly return to normal values in clean water (Moore, 1971). The most sensitive aquatic organisms appear to be filter-feeding molluscs. Marine organisms appear to be more tolerant of fluoride than freshwater organisms, perhaps because sea water usually contains up to ten

times as much fluoride as fresh water. Most studies which have shown toxic effects of marine organisms have all used concentrations which exceed 5 ppm in sea water. Many studies using much greater concentrations than this have found no effects (US EPA, 1980; WHO, 1984).

4.4 FRESHWATER ECOSYSTEMS

A wide variety of freshwater fauna have been exposed to a range of fluoride concentrations in the water and results have shown that there are large differences between species in fluoride tolerance and that other environmental conditions have a considerable influence on the response. Concentrations up to 1.5 ppm in water appear to have no adverse effects on freshwater fauna (US EPA, 1980), but little information is available on the effects of fluoride on freshwater ecosystems.

4.5 NATURAL FOREST ECOSYSTEMS

Trees are exposed to greater amounts of fluoride than shrubs or grasses, and the air within a forest has lower concentrations of fluoride than the air above it, because fluoride is highly reactive and is removed from air by exposure to foliage.

In forest ecosystems fluoride accumulates in leaves and may be transferred to the soil surface with litterfall. As a result of this and dry deposition directly to litter on the soil surface, fluoride concentrations in plant litter may be considerably higher than in green leaves (Murray, 1985). It is possible that when these fluoride concentrations are particularly high there may be some inhibition of litter decomposer activity due to toxic effects on the soil organisms. However the most significant feature of nutrient cycling in these forest ecosystems is fire, which results in the release of nutrients to the soil for root uptake by the flora.

Fluoride is released from plant litter by fire and it has been estimated that about 70% is exported from the ecosystem as gaseous and particulate fluoride, with 30% remaining as ash. High soluble fluoride concentrations occur in the ash and have been found to measure about 1600 $\mu\text{g/g}$ after a bushfire around an aluminium smelter. These concentrations could also impede germination and seedling growth for a period of time but rainfall will ultimately leach the water-soluble fluoride into the soil. Most soils have a high capacity to bind fluoride in an insoluble and unavailable form, and the factors responsible for this are iron, aluminium, calcium and other agents.

Some sandy soils lack these factors and may not have this capacity, and consequently there maybe some potential in these soils for fluoride to be taken up by roots, or leached to groundwaters.

Fluoride was used for many years as a fungicide and so it is possible that high concentrations of fluoride at the soil surface may influence soil fungi and other microorganisms which assist plants to survive in low nutrient soils, but there is no direct evidence of this.

Fluoride has been used commercially as an insecticide and has been shown to alter the growth and reproduction of some insect species feeding on plants containing high fluoride concentrations (Laurence, 1981). Major outbreaks of insect attacks occurred in forests around aluminium smelters and it has been suggested that fluoride-insect interactions were responsible (Alcan Surveillance Committee, 1979).

It is also possible that fluoride could interact in some way with pathogens such as *Phytophthora cinnamomi* which may induce dieback and other forest diseases but there is no information available to assess this possibility.

A number of studies have suggested that fluoride is accumulated along food chains, but there is little evidence in relation to the ecological consequences of this bioaccumulation. Fluoride is known to occur naturally in organic forms such as fluoroacetate (the active ingredient in the poison, 1080) and a number of West Australian plant species contain this poison (poison peas of the genera *Oxylobium* and *Gastrolobium*). About fifteen years ago it was suggested that agricultural plants could produce fluoroacetate from fluoride in the air but extensive field and laboratory studies have been unable to find this compound in vegetation exposed to fluoride (Weinstein, 1977). The absence of reports of organofluoride toxicity in domestic animals grazing around major fluoride emission sources also implies that the original suggestion that agricultural plants could produce this poison when exposed to fluoride was incorrect.

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APPENDIX J

SUMMARY

COMMUNITY NEEDS STUDY

A SOCIO-ECONOMIC AND SOCIAL IMPACT ASSESSMENT

OF THE PROPOSED KEMERTON ALUMINIUM SMELTER

by

DAMES AND MOORE, 1985

(Reproduced in full)

APPENDIX J

COMMUNITY NEEDS STUDY

A SOCIO-ECONOMIC AND SOCIAL IMPACT ASSESSMENT OF THE PROPOSED KEMERTON ALUMINIUM SMELTER

1. SUMMARY AND MAJOR RECOMMENDATIONS

1.1 INTRODUCTION

This study has been commissioned by the Department of Resources Development (DRD) on behalf of the Western Australian Government in order to consider the social and economic impacts and consequent community needs, arising from the development of the Kemerton Aluminium Smelter by the International Aluminium Proponent of Western Australia. The proposed smelter site is located in the southern portion of the Shire of Harvey, and is approximately 10km from the township of Australind and 24km from the regional centre of Bunbury.

This summary outlines the study requirements, its methodology and the structure of the full report, together with its major findings and recommendations.

1.2 STUDY REQUIREMENTS

The terms of reference for the study were forwarded to Dames and Moore by the DRD after discussion with the Department of Conservation and Environment. The aim of the study is:

- To provide baseline social information against which the projected social impact of an aluminium smelter in the South West Region can be assessed.

The prime components of this are:

- provision of adequate baseline data;
- provision of information which will enable an assessment of the conclusions made in the proponent's Environmental Review and Management Programme (ERMP), regarding social impacts;
- identification of agencies responsible for providing facilities and services needed to minimise or offset social impacts;
- assessment of the ability of the various agencies to meet these demands within the time frame of smelter construction and operation, including the ability to finance such demands.

1.3 METHODOLOGY AND STRUCTURE OF THE DOCUMENT

The basic methodology for carrying out the study was, firstly, to analyse the existing socio-economic environment and consider how it might change without the influence of the smelter project. Impact analysis of likely scenarios of development with the project were then completed. Where adverse effects were identified for a particular element of the environment, a set of mitigations and management programmes were recommended.

Two geographic levels of analysis were completed. One covered an area within 60km or 40 minutes travelling time of the site and the other focussed on the local community in the southern half of Harvey Shire.

This summary outlines the major findings, mitigations and recommendations from the four main analytical chapters.

The four main chapters contain analysis and discussion of:

- population and employment;
- housing, social and physical infrastructure;
- local community attitudes and perceptions;
- transportation.

The recommendations are considered to form the basis around which discussions will be held between the DRD and the International Aluminium Consortium of Western Australia concerning the provision of adequate social and physical infrastructure.

1.4 MAJOR FINDINGS AND RECOMMENDATIONS

1.4.1 POPULATION AND EMPLOYMENT

- Distinction between the local and non-local components of the project workforce was the 60km or 40 minute commuting boundary.
- Two population scenarios were developed for analysis of the population and employment impacts of the construction phase. A high component of the construction workforce will come from non-local sources as a high propensity to commute has been observed in other similar construction projects. The estimated numbers of incoming workers are shown in Table J.1
- Two population scenarios were projected for the operational phase. Population increases in this phase are modest in comparison to those of construction (Table J.1).
- Unemployment and underemployment in the labour impact area have been slowly increasing over the past two years. Substantial numbers of local people, who are presently unemployed, are considered to be suitable for the semi-skilled and unskilled jobs at the smelter during its operational phase.
- In order to maximise the benefits for youth employment in the area, an apprenticeship training scheme is recommended. This should be based on the principle of training within the earliest practical time, of apprentices equivalent in number to the permanent tradesmen employed when the project is fully operational. From then onwards, a ratio of at least one apprentice to every three, day-shift tradesmen employed should be maintained.

Table J.1 Summary of Population Scenarios

	Commuting Scenario	Maximum In-Migrant Scenario
Peak Construction Phase		
Daily Commuters	105	158
Weekly Commuters	630	945
In-Migrants	315	472
Local Workers	450	625
Total Workers	1500	2200
Operational Phase		
Local Smelter Jobs	480	480
In-Migrant Smelter Jobs	320	320
Total Smelter Jobs	800	800
Population Increase due to (including In-Migrant Smelter Jobs)		
In-Migrant Jobs:		
• Bunbury	304	554
• Australind	261	498
• Eaton	196	362
• Harvey, Brunswick Junction and other areas in Harvey Shire	89	116
TOTAL POPULATION INCREASE	851	1530

1.4.2 HOUSING, SOCIAL AND PHYSICAL INFRASTRUCTURE

a) Housing

- Two construction village sites, each capable of accommodating 400 workers, are recommended for the construction phase. One possible site could be near the intersection of Treasure Road and the Old Coast Road. This site should have suitable flexibility in its design to allow accommodation for married in-migrant workers with children. A second suitable site is on Marriott Road in the immediate vicinity of the site but physically separated from construction areas.

- Considerable numbers of construction workers will seek accommodation outside the village areas. No accommodation conflict is foreseen with tourist use for the commuting scenario. However, in the worst case scenario, outside caravan park accommodation will be at capacity. Monitoring of the growth of the construction workforce is recommended as one of the duties of the Community Liaison Officer.
- No housing shortages are foreseen in the operational phase for project workers but an increase in rents is likely during the transition from construction to operations. This will induce a small proportion of caravan park operators to provide more permanent sites. Some displacement of non-project population from rental accommodation may be anticipated.

b) Education Facilities

- Facilities are already at capacity at Australind Primary School and at High Schools in Bunbury. It is recommended that additional facilities be available within six months of the commencement of construction. Pre-school facilities are at capacity in Australind and more facilities will be required. Provision of facilities should be closely monitored by the Infrastructure Liaison Committee in co-operation with the Planning Branch of the Education Department.

c) Health Service and Facilities

- Assuming no change in the standards for the provision of hospital and allied services, the additions to hospital services already planned will be adequate to mitigate the impacts of the project. The addition of medical practitioners to the area as population increases will keep general medical services at an adequate level. Monitoring of the level of services by the Community Liaison Officer in consultation with the Department of Health will allow any additional demand to be mitigated accordingly.
- Infant Health services, particularly in Australind, are inadequate and this deficiency will be exacerbated by the influx of young families attracted by the project.

d) Community Organisation and Support Services

It is anticipated that the project will lead to some additional demand being placed on community support services and facilities, particularly in Bunbury.

As the construction workforce, particularly the construction village component, has different health and welfare needs to the existing population, there is a requirement for a trained welfare professional to be available to those workers in the construction village.

Areas of community support that will be affected by the project are:

- women's counselling and support services;
- child care services;
- social and counselling services, particularly 'crisis intervention' within family groups.

Monitoring of the need for these services is recommended especially in the construction phase.

e) Other Infrastructure

- No significant impact is anticipated on other infrastructure with the exception of public security. Monitoring of the public security situation is presently carried out by the W.A. Police Planning Branch. It is recommended that the Community Liaison Officer maintain effective liaison with the Police Department to ensure that present service standards are maintained.

1.4.3 LOCAL COMMUNITY ATTITUDES AND PERCEPTIONS

- Due to the level of concern expressed over the perceived effects of fluoride, further workshops similar to the one recently held in Australind should be conducted. The objective of these workshops would be to re-iterate material already presented and to outline the proposed fluoride monitoring programme for the smelter. Such workshops should consider the effects of fluoride on humans as well as animals and give adequate consideration to the effects of fluoride in the specific climatic conditions of the study area. Further exposition of the advantages of this site compared to the Worsley Site should be presented from a fluoride impact viewpoint.
- There is a strong perception that the advent of the smelter will affect existing community structure and lifestyle. This concern is also bound up in the concern over possible pressure to further change land-use in the study area toward similar industrial uses. It is recommended that Government should recognise the concerns of the Harvey Shire Council that no additional industrial development be undertaken on the site. Such a policy should be adopted as part of the Bunbury Regional Plan.
- In order to ensure that adequate benefits of development can indirectly flow through to residents of the study area in the longer term, it is recommended that the site should be subject to the payment of local government rates consistent with its industrial use. If there are legal technicalities preventing industrial rating, the proponent and Harvey Shire Council should agree on an equitable contribution to local government, based on equivalent industry in the Shire.

- During the construction phase of the project, and in the transition to operation, there will be a significant increase in the population of Harvey Shire.

It is recommended that an Infrastructure Liaison Committee be formally constituted under the direction of the Co-ordinator of the DRD. The Committee will be formed from representatives of the DRD, Harvey Shire, State Government and proponent personnel and will be responsible for ensuring future infrastructure needs are met. It is recommended that during construction a Community Liaison Officer be appointed to Harvey Shire Council at proponent expense to report to the Infrastructure Liaison Committee and carry out the following functions:

- i) Develop at the Shire level a social monitoring programme concentrating on:
 - (a) the need for additional construction village accommodation
 - (b) specific social needs of the incoming population which may be different to the present structure of social services
 - (c) specific social needs of the existing community which have been affected by the smelter development
 - (d) the status of educational facilities in Australind and Eaton.
- ii) Develop and manage the project already proposed by Harvey Shire Council to build a multi-use early childhood centre in the Australind area serving both Australind and Eaton areas. This centre would provide play-group and formal day care services as deemed necessary by the Infrastructure Liaison Committee. Capital funding for this project should come from proponent sources (50%), State Government and Local Government (50%). Because of the time-lag involved in State and Local Government budgeting, it is recommended that the proponent provide 100% of funding with 50% as a non-interest bearing loan to be reimbursed out of State Government charges and Local Government rates.
Staffing and maintenance of this facility would be the responsibility of the Harvey Shire Council. Funding would then be based on a user pays principle supplemented with normal subsidies from the Federal Government.
- iii) To maintain effective liaison with the South West Development Authority and other State Government Departments to enable the Infrastructure Liaison Committee to ensure prompt remedial action is taken if monitoring identifies a problem in the delivery of normal services.
- iv) The position of Community Liaison Officer should be maintained for the first two years following plant commissioning.
- v) The Community Liaison Officer will also provide a direct service to the employees of the proponent through assistance with the organisation of housing (especially transitional housing) and counselling on family problems due to social readjustment.

1.4.4 TRANSPORTATION

a) Existing Transportation Network

The regional transport network comprises four separate transport facilities. These are:

- road;
- rail;
- air;
- port.

Adequate capacity has been identified for each of these facilities.

The existing local road network will sustain the most significant transportation impacts from the proposed smelter. Roads located within the immediate area of the proposed site have been identified and information on the characteristics, function, dimension, surfacing and traffic volumes provided. These roads are:

- Old Coast Road
- South Western Highway
- Marriott Road
- Wellesley Road
- Partridge Road
- Treasure Road
- Melville Road
- Clifton Road
- Harvey-Myalup Road
- Forestry Road.

b) Assessment of Impacts

- Marriott Road, in its present condition would be unable to accommodate traffic volumes anticipated during either the construction or operation stages of the development.
- The Old Coast Road/Marriott Road intersection also has insufficient capacity to handle the projected peak traffic movement associated with the construction stage.
- Traffic volumes associated with the construction period indicate the need to ensure that access to the site is available from more than one direction. If access is confined to Marriott Road between the site and the Old Coast Road, congestion is anticipated during the peak traffic movements.
- The use of Partridge Road by materials handling traffic during the construction stage and workforce traffic during both stages can be expected. Existing pavement conditions and driving safety would deteriorate as a result of this increased traffic.
- The use of agitator trucks to deliver concrete to the site from a local concrete operator would generate a high level of concentrated truck movement for the duration of a concrete pour. The establishment of a batch plant adjacent to the site is recommended for providing concrete.
- Marriott and Wellesley Road will provide access for the delivery of fill from the site to the sections of the proposed rail corridor east of Wellesley River. Consequently significant truck movements will be generated along these roads between the site and rail corridor during the construction of this facility.

c) Mitigations

The following mitigations are recommended:

- The provision of an access road of suitable standard from the Old Coast Road to the proposed site.
- The upgrading of the Old Coast Road/Marriott Road intersection, incorporating right and left turn lanes out of Marriott Road and the improvement of sighting distance to the north from Marriott Road.
- The sealing of the eastern section of Marriott Road between the site and Wellesley Road. This would also include the provision of two new crossings over existing irrigation drains; the first just west of the Wellesley River and the second approximately 1km west of Wellesley Road.
- The widening of an existing 3.6m wide section of Wellesley Road adjacent to the Marriott Road intersection, to a width conforming with the remainder of the road.
- Financial contributions towards maintenance costs associated with light vehicle increases on Treasure Road and any local road used by haulage vehicles delivering hard fill material to the site. These contributions should be agreed in advance between the Harvey Shire Council, W.A. Main Roads Department and the proponent.
- The establishment of a traffic monitoring programme to record traffic data. This will provide the basis for identifying any potential problem areas and the efficient management and operation of the existing transport network.
- Recommended funding arrangements are detailed in Chapter 5 of the full report.

APPENDIX K

COMMITMENTS AND KEY STATEMENTS BY PROPONENT

APPENDIX K

COMMITMENTS AND KEY STATEMENTS BY PROPONENT

The document which contains a specific commitment is stated at the end of each commitment and, where appropriate, the section and paragraph number, question number or submission number are also given. The documents are abbreviated as follows:

- A — ERMP
- B — Supplement to Draft EIS
- C — Response to the Authority's Questions
- D — Response to Government Agency Comments

The commitments are grouped under four headings:

- General
- Technology
- Environmental Management
- Social Management

GENERAL

The proponent proposes to construct a plant to produce aluminium by the electrolytic reduction process. It incorporates the latest proven technology for both process and emissions control. The plant will be designed and operated in such a way as to:

- minimise source emission levels
- maximise pollutant stream capture efficiency
- optimise treatment or re-use of collected pollutant streams
- appropriately manage the plant site

(A, 6.3.1, para 2)

Subject to geotechnical and hydrological confirmation, the plant will be located as indicated in this document, such that air quality impacts are confined as far as possible to the Government controlled property. Any proposed change will be the subject of both consultation with the State and, if necessary, the provision of information describing the environmental implications of any move.

(A, 6.2, para 2)

The construction phase of the project will generate an average of 800 and a peak of 1,500 jobs over its three year duration. No significant lasting impact is expected to be recorded in the regional population. The provision of a well equipped construction camp, the encouragement provided to others to augment existing levels of supply of temporary accommodation, and a commitment to continuing liaison with Local and State Authorities are expected to act together to reduce the level and possibility of social impact during this phase of the project. On-site measures aimed at controlling water and air-borne emissions will minimise any physical impacts experienced by surrounding land owners. The establishment of the plant on a largely cleared area of dryland pasture means there will be no loss of valuable biological resources.

(A, 4.11.4, para 1; A, 4.11.5, para 4; A, 6.9.2, para 1; A, 7.6.1, para 5)

The project will use electrical energy supplies from the State interconnected grid. Until the Year 1995, surplus gas from the North West Shelf will be used to generate approximately one half of the requirements. The balance, until 1995, and the total thereafter, will be generated from Collie coal. On the basis of current information, the project will consume approximately four per cent of currently commercially developed primary energy resources.

(A, 7.5.10, para 2)

Decision (on the location of the construction camp) will be made by proponent in consultation with DCLM, controllers of Government owned land. Camp will be located to be as near work site as possible, to be hidden from view (especially from major traffic route, Old Coast Road) and to minimise interaction with surrounding residences.

(C, 35)

Yes, (the proponent intends to form a Management Committee prior to the construction phase of the project), although the details have not yet been discussed.

(C, 41)

Should engineered landfill either on or off-site be the adopted procedure, the proponent accepts in principle the concept of a trust fund (established by them and contributed to by reference to the quantity of cathode waste disposed of in the landfill), whose purpose would be to provide funds to monitor the effectiveness of the disposal method and fund any remedial works.

(A, 6.4.1, para 7)

The proponent will provide agricultural, horticultural and veterinary advice to surrounding land owners on matters relating to their continuing operation in proximity to the plant.

(A, 6.9.2, para 7)

No decision has been made on decommissioning. The proponent intends to constantly review the opportunities for beneficial use of the site in the future.

(A, 4.15, para 1)

The proponent would either maintain construction of the site or the finished plant on a care and maintenance basis to allow reactivation of the project as soon as circumstances change.

(A, 4.14, para 2)

The Kemerton plant will not sterilize any known mineral deposits.

(A, 7.5.9, para 2)

The proponent will abide by all terms and conditions established by the State Agreement Act.

(C, 1)

The proponent will prepare an Environmental Management Programme (EMP), for submission to the State for approval within the terms of the State Agreement, when project details are better defined. The EMP will take account of recommendations made in the Authority assessment of the ERMP, and the findings of studies currently being undertaken on behalf of the Authority.

(A, 1.6.2, para 7; A, 6.10, para 1)

The proponent will be responsible for any environmental impact due to its negligent failure to operate the plant in accordance with environmental provisions agreed with the State under or pursuant to the State Agreement Act.

(A, 6.9.2, para 11)

Liaison will be maintained with Local and State Authorities under the terms of the State Agreement Act with a view to both predicting and/or monitoring any impacts on the social and community infrastructure of the area, and deciding any necessary ameliorative measures.

(A, 4.11.5, para 4; A, 6.9.2, para 6)

The results of the monitoring programme will be used to optimise plant operations, and to adjust management practices in surrounding areas. The results will be reported to the relevant authorities as provided for under the ratified State Agreement Act and in accordance with any other relevant legislation.

(A, 6.10, para 2)

Should it prove necessary to move the plant site such that a significant additional area of surrounding land beyond the Government controlled area is impacted by damaging levels of fluoride this will be reported to Government. Should it prove necessary to import from outside the Government controlled area significant additional fill material this will be reported to Government.

(D, 5)

TECHNOLOGY

The plant will employ best practicable technology throughout. The most significant examples are as follows:

- computer controlled CWPB cells, with integrated roof and ends, constant section anode stems, and ribbed hoods, designed to minimise cell emission rates and maximise fume collection efficiency.

(A, 4.4.2, para 4)

- alumina dry scrubbing of both pot fume and anode bake oven fume, removing 97% of all air-borne fluoride generated by the process.

(A, 6.3.4, para 1)

- shot blasting of spent anodes prior to recycling, to reduce the potential for emissions from the anode bake oven.

(A, 4.4.2, para 13)

- natural gas firing of anode baking furnace and cast house, to prevent emission of sulphur dioxide.

(A, 4.4.2, para 12)

- extraction and filtration systems to minimise dust emissions.
(A, 4.12.2, para 4)
- engineered noise controls, including effective silencing or enclosure of major noise emitting operations.
(A, 6.6.1, para 1)
- recirculating cooling system to minimise makeup and discharge quantities.
(A, 6.5.2, para 3)
- collection, treatment and controlled discharge facilities for contaminated process water and plant area runoff.
(A, 6.5.2, para 3)

The plant will be started at a controlled rate averaging 3 cells per day. At no time will more than 25 cells be brought on-line in any one week period.

(A, 6.3.2, para 34)

The proposed plant will have 480 pots, spread evenly between four long low buildings known as potrooms. Each pot is capable of producing about 1.5 tonne of aluminium per day.

(B, 2.3, para 3)

Some or all of the petroleum coke, pitch and aluminium metal may be transported by road from and to the Port of Bunbury. In the worst case, assuming all such material is road hauled, a total of 84 two way truck movements will be recorded daily.

(A, 7.5.3, para 13)

A rail link will be constructed to the plant from the South Western Railway, approximately 9 kms to the east.

(A, 4.8.2, para 1)

Alumina will be supplied from nearby refineries by rail, using dedicated covered hopper wagons. One train load will be delivered daily, 6 days per week.

(A, 4.8.2, para 2)

Petroleum coke and pitch will be delivered to a new facility to be constructed in the inner harbour at Bunbury. No final decision has been made as to the subsequent method of transfer to the plant.

(A, 4.8.2, para 3)

The lesser quantities of aluminium fluoride, cryolite, cathode blocks, soda ash and refractories are likely to be shipped to Fremantle, and subsequently transported by road to the plant. Approximately 450 truck deliveries will be required per year.

(A, 4.8.2, para 4)

Alumina, coke and pitch delivered to the site will be unloaded directly into closed storage.

(A, 4.8.2, para 5)

Alumina will be transferred to the dry scrubber and then to the pot tending assemblies by fully enclosed conveyors and airlifts. Feed to the hoppers located on top of each pot will be by a closed coupling from the pot tending assembly.

(A, 4.8.2, para 6)

Coke and pitch used in anode manufacture will be transferred from storage silos to the carbon plant by fully enclosed conveyors.

(A, 4.8.2, para 7)

Natural gas, fuel oil, liquified propane gas, automotive fuel and oils and lubricants comprise the only hazardous materials on the site.

(A, 4.8.3, para 1)

Delivery of bulk fuels to the site will be made by both rail and road tankers. All storage and transfer facilities will be constructed and operated in accordance with accepted engineering and legislated standards.

(A, 4.8.3, para 7)

A fully equipped laboratory will be used to monitor plant performance, product quality control and compliance with relevant emission standards.

(A, 4.4.2, para 19)

Operation of the pollution control equipment will be given priority in the event of power reductions whilst emissions of fluorides continue.

(A, 6.3.3, para 8)

A benefit/cost study for such a hood will be undertaken at the design stage (collection hood ducted to the primary fume collection scrubbing system).

(D, B.1.4)

Aluminium oxide and bath ladle skimmings will be sold for the recovering of aluminium. Responsibility for the disposal of any by-products will rest with the reprocessor.

(B, 5.6.2, para 4)

ENVIRONMENTAL MANAGEMENT

The proponent is committed to the ongoing protection of the environment should the project proceed.

(A, 6.1, para 2)

A comprehensive monitoring programme will be developed covering:

- the measurement of source emission levels
- the measurement/assessment of relevant environmental indicators.

(A, 6.10, para 1)

The following variables will be measured and assessed, where relevant, at monitoring sites within the 400 ha freehold area, within the Government controlled property, and beyond the Government controlled property:

- ambient air quality and meteorological conditions
- surface and groundwater quality
- forage fluoride levels
- health and growth rates of planted pine
- livestock condition
- noise levels (plant and traffic generated)
- functioning of selected representative ecosystems, including wetlands and the retained native woodland to the west.

(A, 6.10, para 6)

A site of approximately 400 ha, currently cleared dryland pasture, will be developed for the plant. The loss of a remnant patch of vegetation 20 ha in area is not rated as significant.

The plant site development is expected to affect neither surface nor groundwater resources in the area.

(A, 7.2.1, para 1; A, 7.2.2, para 1, 2)

An environmental manager will be appointed at a senior level to manage and control matters related to the protection of the environment.

(A, 8.4, para 11)

Construction activities to be undertaken by the proponent will be entirely within the 400 ha freehold area with the possible exception of the need to establish borrow pits in the dune line to the west of the plant site for purposes of winning fill material. This area is proposed to be cleared and replanted with pine in accordance with the Conceptual Land Management Plan for the area.

(B, 5.11.2, para 1)

The results of this work (commissioned by the Authority with funding from the proponent) will be applied to the design of management programmes for the area of woodland directly to the east of Old Coast Road.

(B, 5.12.1, para 2)

The aluminium plant will not compromise any of the features of the Bunbury Region — ocean beaches, the intensely farmed irrigated areas, Leschenault Inlet, forests and rivers of the Darling Scarp.

(B, 5.18, para 1)

Cathode waste will be disposed of using best practicable technology. No cathode waste will be generated until approximately 1992. Both on-site and off-site landfill, which is considered to constitute the best practicable technology currently available, will be investigated. Developments in reprocessing technology will also be monitored, with a view to the adoption of any proven and viable alternative which is shown to be superior to landfill. The finally selected option will be agreed with the State under the provisions of the ratified State Agreement Act.

(A, 4.6.2 para 5; A, 6.4.1, para 7)

From about 1992 approximately 6,500 tonnes of used (spent) cathode material will need to be disposed of annually.

(B, 2.6, para 1)

The proponent will produce an information sheet for distribution to contractors, pointing out matters of relevance to environmental protection.

(A, 4.11.5, para 2)

The environmentally sensitive areas in the region will be defined and described (in the 'information sheet' on environmental protection). The project manager will in all likelihood then prepare detailed guidelines for site personnel, taking account of any sensitive surroundings, as for major projects in recent years.

(C, 36)

The aluminium plant development will not lead to any increase in bauxite production from the Darling Plateau beyond that already provided for in the relevant enabling legislation.

(A, 7.5.9, para 1)

Volatiles in the anode manufacturing process (derived from the coal tar pitch) will be removed by exhaust fans, and the collected fume scrubbed with coke prior to discharge to atmosphere. In this manner, both internal and external concentrations will be minimised.

(B, 5.9.1, para 8)

A total of approximately 2,550 tpa of non-contaminated refractory bricks will require disposal annually. This material has been designated for removal to municipal landfills to sites agreed with the relevant authorities, where it can be used as the inert covering material required on a daily basis for spreading over putrescible wastes.

(B, 5.6.2, para 2)

The water management programme will not be finalised until the fluoride fixing capacity of the soil profile has been determined. The programme will be designed such that site activities have minimal impact on both surface and groundwater quality. The wetland areas to the north west and south east of the site may register a slight increase in soluble fluoride levels. At the levels anticipated, there is unlikely to be any adverse impact on the aquatic ecosystem. No other measurable effects on either the quality or availability of surface or groundwater flows are anticipated.

(A, Summary, p.xiii)

Actual bore developments will be subject to PWD approval.

(A, 4.9.3, para 2)

Runoff controls will be established at the outset of construction to prevent the discharge of water with high levels of suspended solids from the area of construction activity.

(A, 4.11.2, para 2)

Trafficked areas will be sprayed with water to minimise the potential for the generation of dust emissions.

(A, 4.11.2, para 3)

The proponent will monitor fluoride levels in water tanks of homes beyond the Government controlled area, but in proximity to plant, and provide appropriate water treatment equipment should levels rise beyond 1 ppm.

(A, 6.9.2, para 12)

Runoff controls will be established to prevent the uncontrolled discharge of sediment loaded flows into waterways.

(A, 7.2.2, para 3)

Rainfall will dissolve available fluoride from roofs etc. It is expected that a maximum concentration of 10 mg F/L may be achieved in the first flush of rainfall.

(A, 4.7.1, para 2)

There will be no uncontrolled discharge of water containing in excess of 1.5 mg/L fluoride from the plant area. The final water management strategy will be determined only when the results of tests investigating the fluoride fixing capacity of the soil profile become available. Details of the final strategy will be provided in the EMP.

(A, 6.5.2, para 3; A, 7.4.5, para 3)

The plant will be operated such that airborne fluoride emissions do not exceed 1 kg F/t.Al (one kilogram of total fluoride per tonne of aluminium produced) on a long term basis.

(A, 6.3.4, para 1)

On the basis of a 3% sulphur content of the petroleum coke used in anode manufacture, 24.8 kg of SO₂ will be generated for each tonne of aluminium produced.

Sulphur dioxide is not removed in the dry scrubbing process proposed for fluoride control and is consequently discharged to the atmosphere via the scrubber stacks. A total of 5,382 tpa will be discharged in this manner.

A further 138 tpa will be discharged from the potroom roof vents, representing the cell emission which evades capture by the hooding and exhaust system.

An additional 184 tpa will be discharged from the anode baking furnace scrubber stack.

(B, 3.1.2, para 1-4)

The highest annual concentrations (of SO₂) between 4 and 5 µg/m³ are expected to occur in the area located to the west-north-west of the plant. The second largest annual concentrations were predicted for the area to the east of the plant.

Outside these two areas, the annual concentrations are expected to remain below 4 µg/m³.

A maximum 24-hour level of approximately 60 µg/m³ was calculated, rising to 205 µg/m³ over a 3-hour averaging period.

(B, 3.1.4, para 1-4)

The possibility of non-malignant respiratory disease arising from exposure to dust (alumina, coke, cryolite, etc) will be minimised by providing extraction and filtration equipment to all confined dust sources. A high standard of housekeeping will be maintained by regular sweeping/vacuuming of all work and trafficked area. Any raw material spills will be immediately attended to.

(B, 5.9.1, para 5)

No asbestos will be used in cast house operations (or elsewhere).

(B, 5.9.1, para 6)

It is the proponent's objective to minimise the visual intrusion of the plant within its surroundings.

(A, 6.7.1, para 2)

The plant will not be visible to travellers on Old Coast Road to the west. It will not be visible to existing rural residential developments. It will, however, be in the line of sight of observers on Wellesley Road, and points further east up to and including the western face of the Scarp. The level of impact in these latter cases will be minimised as a result of the viewing distances involved, and the likely familiarity of most of the observers with the changing landscape.

(A, 7.4.6, para 1, 2 and 3)

Domestic waste will be disposed off site.

(A, 4.6.2, para 6)

Sewage will be treated on site in a package plant.

(A, 4.9.4, para 1)

The impact of site operations on community noise levels is assessed as being slight.

(A, 7.5.4, para 3)

The operation of the plant will not significantly affect the overall yield of softwood plantations established within the State controlled area. There may be a need to adopt specific management practices to restrict the dietary intake of fluoride of stock grazing within the plantation area.

(A, 7.5.7, para 2)

The major effect of the plant beyond the pine plantings is the possible decline in the number of marri. As this is not the most abundant tree species over the site, the overall change in structure of the woodland is expected to be small. The vegetation of the wetland areas is unlikely to be affected.

(A, 7.2.2, para 1)

The valuable wetland resources near the site will be untouched by the construction operation.

(B, 5.11.2, para 2)

Shelter-belts/filter-zones of trees will be planted and tended on that portion of the 400 ha site operational and safety constraints allow.

(A, 6.3.5, para 1 & 11)

Dairying activities to the east of the Wellesley River will suffer no adverse economic impact as a result of airborne emissions from the proposed plant, providing fluoride intakes from sources such as phosphate supplements are not excessive. Management practices on dryland grazing properties to the north of the site may need to be modified slightly to take account of possibly elevated forage fluoride levels during summer.

(A, 7.5.5, para 6)

Areas of forage cropping to the west of the plant, and orange groves to the north west, are not expected to suffer economic impacts as a result of emissions from the plant.

(A, 7.5.5, para 10)

There may be minor limitations imposed on the choice of garden plants grown in rural residential developments to the north, east and south west of the plant. These areas will otherwise be largely unaffected by the proposal in terms of physical pollution. The health of residents living near the plant will be unaffected by airborne emissions.

(A, 7.5.5, para 16)

Piggery and abattoir will not be operating if the plant is constructed, unless proponent agrees with State that they are compatible land uses.

(D, F.7.5.7)

SOCIAL MANAGEMENT

At the completion of the construction phase, the camp will be offered for sale and removed. The site will be planted with trees.

(A, 4.11.4, para 5)

(The construction camp will be sold) by public tender or auction.

(C, 22)

Conditions within the plant will be maintained in accordance with relevant health, comfort and safety standards, and staff and visitors will be supplied with all necessary personal safety equipment.

(A, 4.12.2, para 1-6)

Plant staff will receive routine medical checks, and safety training both at induction and throughout their period of employment. Both formal and on the job training will be provided to a significant proportion of the workforce.

(A, 4.12.3, para 1-5)

The proponent will be guided by the WA Museum as to the need to undertake any further investigations (of Aboriginal sites).

(A, 5.3.8, para 9)

It is the proponent's intention to foster and maintain harmonious relationships with both its workforce, suppliers and the community of which they and the plant will be part.

(A, 6.9.1, para 1)

A construction camp will be established within the proposed Government controlled property. Contractors will be encouraged to avail themselves of its facilities.

(A, 4.11.4, para 2; A, 6.9.2, para 2)

Accommodation (at construction camp) will be single men's sleeping quarters, with centralised ablutions, meals area and recreation facilities. Will be using Atco or similar. No plans to leave for long term tourist accommodation.

(C, 97)

Indoor and outdoor recreational facilities will be provided for residents of the construction camp.

(A, 6.9.2, para 3)

The proponent will encourage private interests to provide or augment facilities to accommodate construction workers in local caravan parks.

(A, 6.9.2, para 4)

The proponent will cooperate in studies aimed at determining the implications of the project on the social environment, by, for instance, providing available information describing the nature and origin of its workforce, and their settlement pattern.

(A, 6.9.2, para 8)

Liaison will be maintained with Local and State Authorities under the terms of the State Agreement Act with a view to both predicting and/or monitoring any impacts on the social and community infrastructure of the area, and deciding any necessary ameliorative measures.

(A, 6.9.2, para 9)

The plant will employ a full-time community relations officer, with broad responsibility for interacting with the local community and its representatives.

(A, 6.9.2, para 10)

(The Community Relations) Officer ... (will) liaise with surrounding community throughout operational phase. Expect fulltime appointment to be at a responsible level, probably at time operational staff hirings commence.

(C, 42)

Most pressure on the social infrastructure will be felt in Harvey Shire in Australind and Binningup. Specific measures will be required in both centres to maintain an adequate level of infrastructure provision.

(A, 7.5.3, para 23)

Guided tours of the aluminium plant will be available.

(B, 5.18, para 3)

ABBREVIATIONS

BRP:	Bunbury Region Plan
cm:	Centimetre
CALM:	Department of Conservation and Land Management
CO:	Carbon Monoxide
CO ₂ :	Carbon Dioxide
dB(A):	Decibels, measurement using frequency weighting network A.
DCE:	Department of Conservation and Environment
DRD:	Department of Resources Development
EIA:	Environmental Impact Assessment
EIS:	Environmental Impact Statement
EMP:	Environmental Management Programme
EPA:	Environmental Protection Authority
ERMP:	Environmental Review and Management Programme
F:	Fluoride
g/L:	Gramme per litre
g/m ² :	Gramme per square metre
ha:	Hectare
HF:	Hydrogen fluoride
kg:	Kilogramme
kg/tAl:	Kilogramme per tonne of aluminium
km:	Kilometre
kV:	Kilovolt
kW:	Kilowatt
m:	Metre
m ³ :	Cubic metre
mg/L:	Milligramme per litre
mg/m ³ :	Milligramme per cubic metre
ml:	Millilitre
mm:	Millimetre
MRD:	Main Roads Department
MW:	Megawatt
MWh:	Megawatt hour
N.O.I.:	Notice of Intent
PER:	Public Environmental Report
pH:	The measure of the degree of acidity or alkalinity
ppm:	Parts per million
PWD:	Public Works Department
SECWA:	State Energy Commission of W.A.
SO ₂ :	Sulphur dioxide
SWDA:	South West Development Authority
tpa:	Tonne per annum
TPS:	Town Planning Scheme
tpy:	Tonne per year
µg/m ³ :	Microgramme per cubic metre

