



EIS 378

AB019077

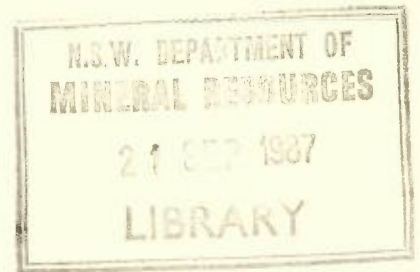
Rare earth processing plant, Tuncester, New South Wales :
development application and environmental impact statement

L87/558

5



ND PTY LTD



RARE EARTH PROCESSING PLANT TUNCESTER, NEW SOUTH WALES

Development Application and Environmental Impact Statement

EIS
378

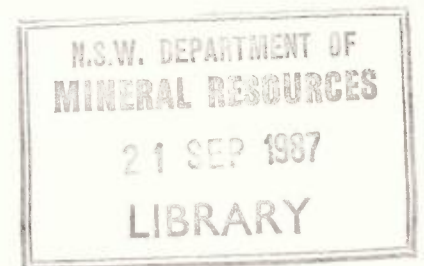
KINHILL ENGINEERS PTY LTD

378

L87-558

RARE EARTH PROCESSING PLANT
AT TUNCESTER, NEW SOUTH WALES

DEVELOPMENT APPLICATION AND
ENVIRONMENTAL IMPACT STATEMENT



Prepared for:

Deckhand Pty Ltd
Currumbin, Queensland, 4223

Prepared by:

Kinhill Engineers Pty Ltd
645 Harris Street
Ultimo NSW 2007

S86060
July 1987

CONTENTS

Chapter		Page
	STATEMENT AND CERTIFICATE SUMMARY	i ii
1	INTRODUCTION	
1.1	Background to the project	
1.2	The Environmental Impact Statement and Development Application process	1
1.3	The proponent	2
1.4	Location, site description and timing of the project	4
1.5	Structure of the report	5 9
2	PROJECT DESCRIPTION	
2.1	Introduction	
2.2	Objectives of the project	11
2.3	Supply of feedstock	11
2.4	Treatment processes	12
2.5	Process chemical requirements	15
2.6	Products and by-products	19
2.7	Process emissions	20
2.8	Utilities and infrastructure	23
2.9	Transport, handling and storage	26
2.10	Waste disposal	28
2.11	Plant refurbishment and commissioning	31
2.12	Operations	35
2.13	Decommissioning	36 36
3	ENVIRONMENTAL ISSUES AND RADIATION	
3.1	Environmental issues	
3.2	Background information on radiation	37
3.3	Radiation protection standards	38 42
4	JUSTIFICATION OF THE PROPOSAL	
4.1	Market demand and government support	
4.2	Advanced technology industries	47
4.3	Economic and other benefits	48
4.4	Alternative sites and reasons for site selection	49
4.5	Consequences of not proceeding with the proposal	50 52

Chapter		Page
5	DESCRIPTION OF EXISTING ENVIRONMENT	
5.1	Introduction	55
5.2	Site development	55
5.3	Land use	59
5.4	Planning provisions	60
5.5	Geology and soils	62
5.6	Meteorology	62
5.7	Hydrology	64
5.8	Transport and access	65
5.9	Background radiation	66
6	ENVIRONMENTAL IMPACTS AND SAFEGUARDS	
6.1	Introduction	67
6.2	Plant refurbishment effects	67
6.3	Land use effects	68
6.4	Infrastructure and energy requirements	70
6.5	Social and economic effects	70
6.6	Traffic and transport effects	71
6.7	Wastewater disposal	72
6.8	Solid wastes disposal	75
6.9	Atmospheric emissions	77
6.10	Health and safety	79
6.11	Risk assessment	85
APPENDICES		
A	Director of Environment and Planning Requirements	
B	Lismore City Council Comments on Proposal	
C	Development Application	
D	Letter from Department of Mineral Resources	
E	Letter from State Pollution Control Commission	
F	Glossary	
G	Abbreviations	
H	References	
I	Study Team	

LIST OF FIGURES

Figure		Page
CHAPTER 1		
1.1	Location plan of the proposed rare earth processing plant	6
1.2	Site plan of proposed rare earth processing plant	7
CHAPTER 2		
2.1	Plan of works required for the proposed rare earth processing plant	13
2.2	Process flow sheet for the proposed rare earth processing plant	17
2.3	Proposed chemical storage bunding plan, section and elevation	21
2.4	Proposed rare earth processing plant process water flows	27
2.5	Proposed rare earth processing plant material flows	29
2.6	Interim waste repository site plan, section and elevations	33
CHAPTER 3		
3.1	Uranium and thorium decay chains	39
CHAPTER 4		
There are no figures in this chapter		
CHAPTER 5		
5.1	Land use and ownership	61
5.2	Lismore meteorological data	63
CHAPTER 6		
There are no figures in this chapter		

LIST OF TABLES

Table	Page
 CHAPTER 1	
1.1 The rare earth elements	2
1.2 Uses of rare earth elements	3
 CHAPTER 2	
2.1 Process chemical requirements and storage	20
2.2 Composition and production of thorium residue	23
2.3 Wastewater 2 radionuclide concentrations	24
2.4 Radium quantities at thorium and uranium separation stage	25
2.5 Wastewater 7 radionuclide concentrations	25
2.6 Loadings of wastewaters	26
 CHAPTER 3	
3.1 Penetrating ability of radiation	40
3.2 Sources of radiation	41
3.3 Radiation protection standards	43
 CHAPTER 4	
4.1 Site selection factors	51
 CHAPTER 5	
5.1 Background radiation levels	65
 CHAPTER 6	
6.1 Infrastructure and energy requirements	70
6.2 Traffic generation from the proposed rare earth processing plant	72
6.3 Estimated activity levels for wastewaters entering the waste treatment plant	73
6.4 Principal sources of radiation from the proposed rare earth processing plant	80
6.5 Radiation protection design criteria	82
6.6 Areas of potential risk	86
6.7 Estimated concentrations and loadings of radionuclides in wastewaters discharged	90
6.8 Wastewater discharge pathways	92

ENVIRONMENTAL IMPACT STATEMENT

This Statement has been prepared on behalf of Deckhand Pty Ltd being the applicant making the development application referred to below.

The Statement accompanies the development application made in respect of the development described as follows:-

To refurbish the existing buildings on site; construct a waste repository, internal access road, chemicals storage bund and other minor works; and therein install and operate a rare earth processing plant and associated safeguards and facilities.

The development application relates to the land described as follows:-

South-east corner of Kyogle and Rifle Range Roads, Tuncester

Real property description: All those parcels of land described in Certificates of Title Volume 3624 Folio 201, Volume 3739 Folio 142 and Volume 5809 Folio 85 in the City of Lismore, Parish of South Lismore and County of Rous together with the improvements erected thereon.

The contents of this statement, as required by clause 34 of the Environmental Planning and Assessment Regulation, 1980, are set forth in the accompanying pages.

Name, Qualifications and Address of
person who prepared Environmental
Impact Statement

Bruce R. Adcock B.A., Dip T&RP,
MRAPI
Kinhill Engineers Pty Ltd
645 Harris Street
Ultimo NSW 2007

Certificate

I, Bruce R. Adcock, of Kinhill Engineers Pty Ltd, hereby certify that I have prepared the contents of this Statement in accordance with clauses 34 and 35 of the Environmental Planning and Assessment Regulation, 1980.

B.R. Adcock
.....
Signature

31st July 1987
.....
Date

SUMMARY

The development proposal by Deckhand Pty Ltd is for the construction of new works and the installation of a rare earth processing plant on a former brewery site at Tuncester near Lismore, New South Wales. The processing plant would extract rare earths from 2,000 tonnes per annum of monazite and xenotime feedstock. No monazite processing is presently being undertaken in Australia, despite the country being the world's largest producer and exporter of monazite. Rare earths have numerous and diverse applications in metallurgy, glass, ceramics, illumination, electronics, chemicals and magnets industries. World demand is growing, particularly as a result of the growth in advanced technology industries that could include industries such as high strength permanent magnets and new ceramics in Australia. As most of the existing buildings, infrastructure and facilities on the site are in excellent condition it is planned that the first output would be available in late 1987 or early 1988. A total of \$7 million would be expended on establishing the plant, which would operate for at least ten years but which would have a life expectancy of at least twenty years before decommissioning.

The proposed rare earth processing plant would have substantial economic benefits for Australia, New South Wales and the Lismore region. The production of 1,100 tonnes per annum of rare earths and other by-products of trisodium phosphate, ammonium sulphate and thorium residue would also encourage the development of associated downstream industries and related advanced technology industries. Development of the rare earth processing plant has both market demand and government support.

The main environmental issues relate to the operation of the rare earth processing plant, associated radiation protection for workers, public health, transport of process chemicals and feedstock, and disposal of solid, liquid and gaseous radioactive wastes and by-products.

The design and operation of the rare earth processing plant would include safeguards so that the environment and the health and safety of workers and the public are protected. Diluted wastewaters and gaseous emissions from the plant would be significantly below derived radiation limits. An on-site interim waste repository, which would have controlled access and protection, would have minor effects on the environment.

A preliminary risk assessment has shown that areas of potential hazard would be low risk, and relevant emergency procedures would be developed. Other land use, social, traffic and transport effects and infrastructure use would be generally less than those of the former site user.

It is concluded that the proposal would meet applicable legislative and government requirements and would have a low and acceptable impact on the environment.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE PROJECT

Currumbin Minerals Pty Ltd (hereafter referred to as Currumbin Minerals) is an Australian sand mining and heavy mineral processing company that produces the mineral sands products of monazite, rutile and zircon. Rutile is used in paint pigments, plastics, welding rods and engineering metal, and zircon is used in the manufacture of heat resisting materials, ceramics, and foundry sand for precision casting, and in chemical industries. Monazite, rutile and zircon are also exported as raw materials with monazite requiring Commonwealth Government approval because of its radioactive content.

Currumbin Minerals now wishes to expand its operation (to gain the benefits of the added-value production) by additional processing of mineral sands to provide a reliable source of rare earths and associated by-products which would help promote Australian high-technology industries and supply export markets. Consequently, Deckhand Pty Ltd (hereafter referred as Deckhand) has been established as a wholly controlled company of Currumbin Minerals in order to develop a rare earth processing plant at Tuncester, New South Wales, that would process rare earths from the monazite currently produced by Currumbin Minerals and other east coast Australian producers.

Most of the world's rare earth feedstock comes from Australia, Brazil, China, India, Malaysia, the USA and the USSR. All of these producers, with the exception of Australia, are also rare earth processors. Despite Australia being the world's largest producer of monazite (approximately 18,000 t/a mainly from Western Australia), there is no rare earth processing plant in the country; a plant did, however, operate at Port Pirie, South Australia during the late 1960s and early 1970s. As there is presently no domestic market for monazite, most of it is exported mainly to France and the USA. The plant proposed by Deckhand would be the only rare earth processing plant in Australia that was wholly owned, operated and managed by an Australian company. Most of the rare earth products would be exported until local high technology related industries were developed. A French company also currently has a proposal for a rare earth processing plant at Pinjarra, Western Australia.

The elements listed in Table 1.1 are known as rare earths because originally they were obtained as earths or oxides from relatively rare minerals. This term is still used, although now the elements are not considered as rare. The rare earth elements, also called lanthanides, are a group of metals with similar chemical and physical properties that make separation of individual elements difficult. Although not a lanthanide, yttrium is also included with the rare earth elements as it often occurs with them in nature and has similar chemical properties. For the purposes of classification, the rare earths can be designated as either light rare earths or heavy rare earths on the basis of atomic weights and chemical properties. Rare earths are contained in monazite and xenotime which are phosphates of mixed rare earths, thorium and small amounts of uranium. Monazite is rich in the light rare earths while xenotime is rich in yttrium.

Table 1.1 The rare earth elements

Group	Element	Symbol	Approximate percentage of rare earth in Australian east coast monazite (expressed as oxide)
Light rare earths	Lanthanum	La	23.4
	Cerium	Ce	47.7
	Praseodymium	Pr	5.0
	Neodymium	Nd	16.9
	Promethium	Pm	(rarely found in nature)
	Samarium	Sm	2.4
	Europium	Eu	0.1
Heavy rare earths	Gadolinium	Gd	1.6
	Terbium	Tb	0.1
	Dysprosium	Dy	0.6
	Holmium	Ho)	
	Erbium	Er)	
	Thulium	Tm)	0.3
	Ytterbium	Yb)	
	Lutetium	Lu)	
	Yttrium	Y	1.9

Rare earths presently have a wide variety of uses in high technology industries. As strategic materials they are being constantly developed as important ingredients for new high technology devices and materials. Some of the applications of rare earths are listed in Table 1.2. The rare earths are used principally as petroleum cracking catalysts, steel alloying agents, glass polishing compounds and glass additives, and are used in permanent magnets and phosphors for television and lighting.

The world demand for some of the rare earths presently exceeds supply. A reliable local supply of rare earths would be a valuable export commodity for Australia and would encourage the development of high technology and downstream industries.

1.2 THE ENVIRONMENTAL IMPACT STATEMENT AND DEVELOPMENT APPLICATION PROCESS

The proposed rare earth processing plant is classified as designated development under the provisions of the New South Wales Environmental Planning and Assessment Act, 1979 (as amended). Paragraph (k) of Schedule 3 of the Environmental Planning and Assessment Regulation, 1980 includes the following type of designated development:

crushing, grinding or milling works, being works in which more than 200 t/a of rock, ores, minerals, chemicals or natural grain products are processed by crushing, grinding, milling or separating into different sizes.

Table 1.2 **Uses of rare earth elements**

Industry	Use
Metallurgy	Alloying agents in iron, steel, magnesium, superalloys, and pyrophoric alloys, lighter flints, pure metals for research, corrosion-resistance, armaments.
Glass	Polishing compounds, decolourizers, colourizers, colour correctors, increase refraction, radiation stabilizer, light absorber, fibre optics.
Ceramics	Colourizer for glazes, vision-protective goggles, high-temperature refractories, combustion engines, metal substitutes, coatings, stabilizers.
Illumination	Phosphors (colour television, X-ray intensifying screens, data displays), mercury vapour lamps, carbon arc lamps, trichromatic fluorescent lamps, gas mantles.
Electronics	Capacitors, cathodes, electrodes, semiconductors, thermistors, computer memories and substrates, missile guidance systems, lasers.
Chemicals	Catalysts, pharmaceuticals, water treatment, chemical processing and analysis, fertilizers, moisture retention.
Magnets	Electric motors, alternators, generators, computer disk-drive actuators, proton linear accelerators, travelling wave tubes, line printers, headphones, speakers.
Nuclear	Control rods, reactor components, burnable poison, shielding, detectors and counters, fuel reprocessing.
Other	Jewellery, paint and ink dryers, textiles, hydrogen fuel storage, refrigerant, lubrication, thermometers, photography.
Source:	United States Department of the Interior (1985).

Development applications for designated development must be accompanied by an environmental impact statement (EIS) prepared by or on behalf of the applicant. Currumbin Minerals has decided to proceed with a proposal for the designated development of a rare earth processing plant and Deckhand subsequently consulted the Department of Environment and Planning in October 1986. The Director of Environment and Planning requirements as to the form and content of the EIS are included in Appendix A. As listed in the requirements, the proponent briefed Lismore City Council senior officers and representatives on 16 April 1987 to enable them to take into account any matters that might apply to Council's determination of the proposal. Council's comments were forwarded on 6 May 1987 and are included in Appendix B.

As the proposal is for a development that might be carried out only with the consent of Council, Deckhand has included a Development Application in this EIS for consideration by Lismore City Council (Appendix C). Council would then

consider whether the EIS and Development Application were adequate and would subsequently notify owners or occupiers of land adjoining the site, and place a notice of the development on the site and in the Northern Star newspaper. A public exhibition calling for public review and submissions would be arranged by Council for a minimum of 30 days commencing from the date of first notice in the newspaper. Council and the Department of Environment and Planning would then consider the submissions, with Council making a determination that took into consideration matters within Section 90 of the Environmental Planning and Assessment Act, 1979. The Minister for Planning and Environment might also direct that a public inquiry be held should any objections warrant an inquiry. The applicant and objectors to the proposal could appeal against any determination to the Land and Environment Court. Should the Development Application be approved, then further applications, licences, permits and approvals would need to be obtained by the proponent before operation of the rare earth processing plant.

1.3 THE PROPONENT

Deckhand, the proponent for the proposal, is a private company formed in 1986 and wholly controlled by Currumbin Minerals. The company was formed for the purpose of developing the rare earth processing plant and would trade under the name of 'Rare Earths Australia'.

Currumbin Minerals is the oldest sand mining company in Australia and has mined mineral sands for 47 years. Because of its expertise in mining extraction and rehabilitation of mined lands, Currumbin Minerals has, in recent years, undertaken clean-up operations for other mining companies and local government bodies. Currumbin Minerals currently employs over 100 people in operations which include:

- . a mine and dry separation plant at Currumbin, south-east Queensland;
- . a tailings retrieval plant at Kingscliff, northern New South Wales;
- . a corporate office in Currumbin that employs people in financial, accounting, general management, supply and marketing functions, and in engineering and corporate services;
- . world wide sales of mineral sands.

Should the project proceed, it is envisaged that the venture partners would include raw material suppliers, and consumers of the plant's output. It is proposed that they would take up part of the equity currently held by Currumbin Minerals who would, however, always hold a minimum 51% controlling interest.

1.4 LOCATION, SITE DESCRIPTION AND TIMING OF THE PROJECT

The site is located in the far north coast region of New South Wales, 5 km west of Lismore at Tuncester on the south-east corner of the intersection of Kyogle and Rifle Range Roads. Figure 1.1 shows a location plan and the regional context of the rare earth processing plant. Figure 1.2 shows the site plan of the proposed rare earth processing plant, including existing buildings, facilities and landscaping.

The site is rectangular in shape (approximately 600m by 220m) and has an area of 13.47 ha. Approximately half of the northern portion of the site has been excavated to form a large platform, with the southern portion remaining as sloping ground. Major improvements on the platform include a modern factory and warehouse complex and associated offices and facilities that were used by a former brewery from October 1979 to March 1986. The main buildings cover over 10,000 m² and are constructed of brick, concrete and metal cladding and are set among landscaped grounds. Facilities on site include car parking areas, gatehouse and weighbridge, external storage and hardstanding areas, fire fighting plant, receiving hopper and materials storage silos, oil storage tanks, powerhouse, caretaker's cottage, water storage tanks, water treatment plant and waste treatment plant. The developed portion of the site is security fenced and is fully serviced with infrastructure including piped water supply, sewerage and drainage systems, electricity supply, refrigeration and compressed air systems, internal and external lighting systems, internal and external communications systems and paved internal access roads. All buildings and structures (both internally and externally), facilities and infrastructure are in excellent condition as the brewery was only constructed in 1979.

The proponent would refurbish the interiors of existing buildings and construct some new works to meet the needs of the rare earth processing plant. Most of the brewery plant equipment has already been dismantled leaving clean structures with clear spans to accommodate new plant. No significant changes are proposed to the external appearance of the site's buildings although some vertical fermenters and air conditioning plant used by the brewery have been removed. Detailed planning and design of the plant would be completed as soon as possible and, subject to other approvals, the first output would be available in late 1987 or early 1988. A total of \$7 million would be expended on the purchase of land and buildings, refurbishment, construction of new works and plant procurement and installation. Tenders would be let for refurbishment immediately following development approval, with works expected to take 3 months with completion later in 1987. The rare earth processing plant would then be installed to process 2,000 t of monazite and xenotime concentrates annually.

It is anticipated that the life of the rare earth processing plant would be a minimum of 10 years and a maximum of at least 20 years, with decommissioning of plant and equipment probably occurring early next century to enable the site to be used by another industry.

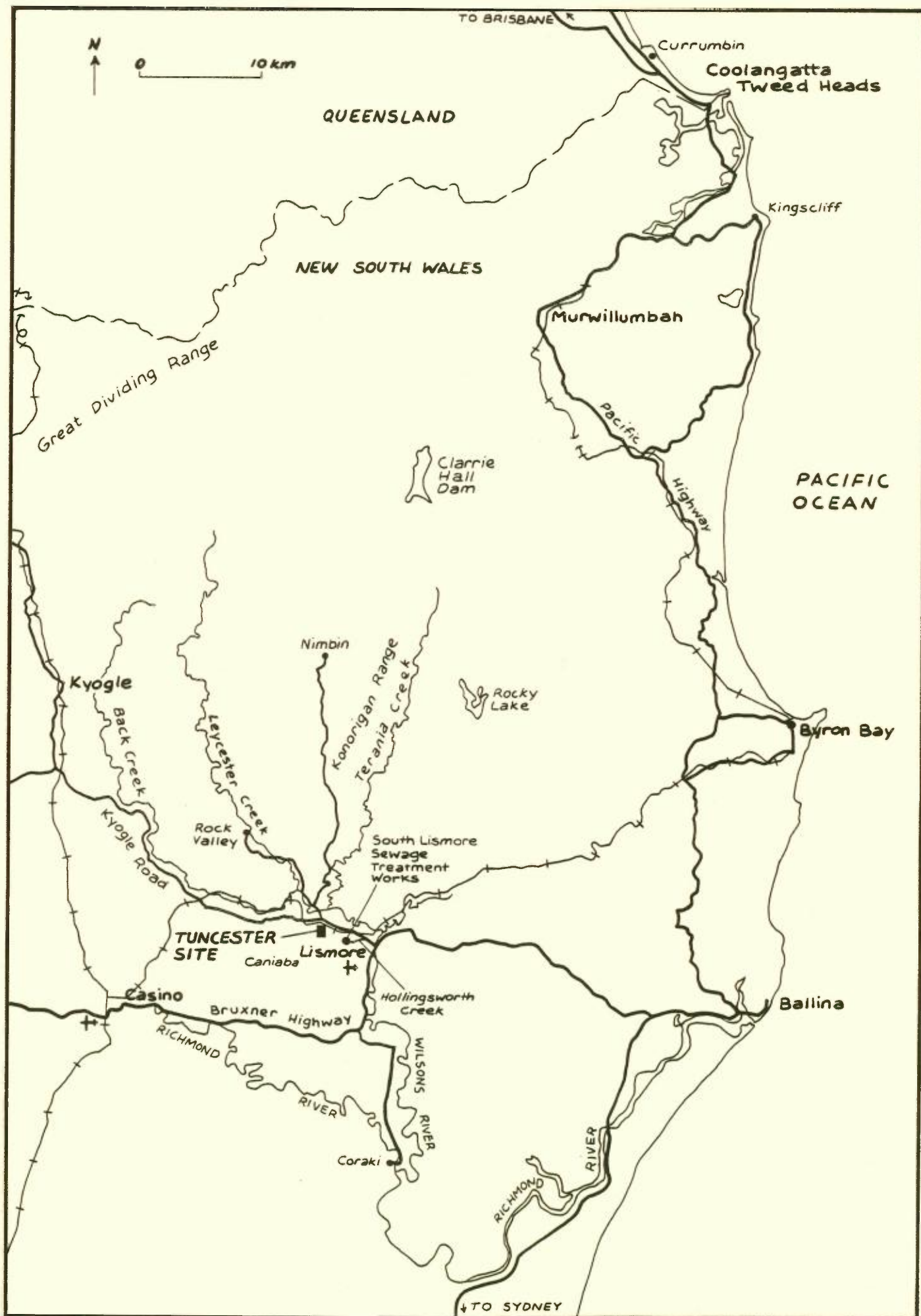


Figure 1-1 LOCATION PLAN OF THE PROPOSED RARE EARTH PROCESSING PLANT

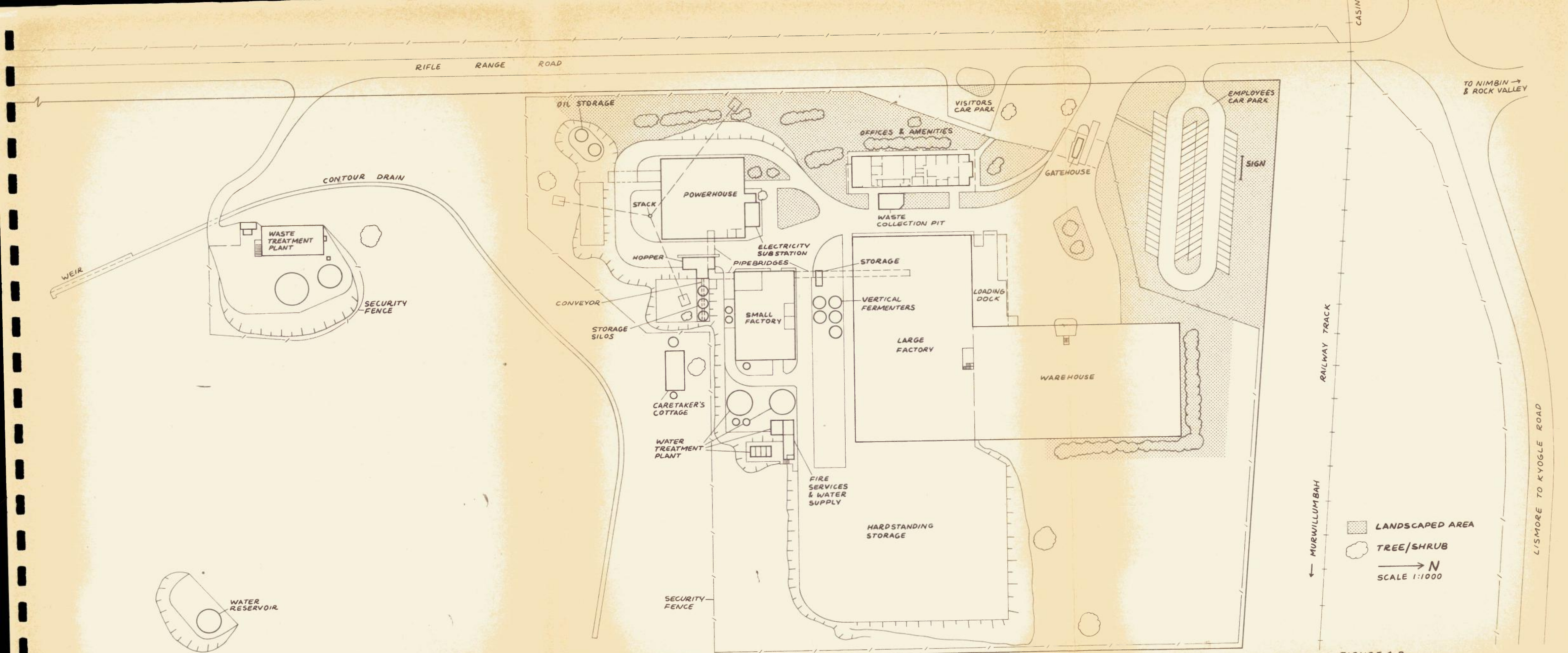


FIGURE 1-2
SITE PLAN OF PROPOSED
RARE EARTH PROCESSING PLANT

1.5 STRUCTURE OF THE REPORT

Chapter 2 involves a detailed project description of the proposed rare earth processing plant including feedstock and material inputs and other operational and infrastructure requirements for the selected chemical process and resultant products, by-products and emissions. Chapter 3 outlines the main environmental issues associated with the proposed plant including detailed background information on radiation and radiation protection standards. Chapter 4 includes the economic justification and government support for the proposal, alternative sites considered and the consequences of not proceeding with the proposal. Chapter 5 provides a detailed description of the existing facilities on site and the existing environment as a base from which to assess the environmental impacts included in Chapter 6. The main environmental issues and their impacts and associated safeguards are detailed in Chapter 6 together with discussion of the special requirements of the Department of Environment and Planning and Lismore City Council.

The Appendices reproduce the requirements of the Department of Environment and Planning and Lismore City Council, the Development Application and letters from the Department of Mineral Resources and State Pollution Control Commission. A glossary of technical terms, abbreviations and references used throughout the EIS are also included as appendices, together with the study team that produced the EIS.

CHAPTER 2

PROJECT DESCRIPTION

2.1 INTRODUCTION

Section 1.4 provided an outline of the scope of the project. In Chapter 2 the objectives of the project are described in Section 2.2. The arrangements which ensure a supply of feedstock for the plant are discussed in Section 2.3. In Section 2.4 the alternative treatment processes considered and the process proposed for the plant are described. The process description provides the basis for identifying the process chemical requirements (Section 2.5), the products and by-products from the plant (Section 2.6), the process emissions (Section 2.7) and the utilities and infrastructure required (Section 2.8). The transport, handling and storage requirements for inputs and outputs from the process are set out in Section 2.9, while the proposed methods of waste disposal are described in Section 2.10. To make the plant operational, plant refurbishment is required (Section 2.11). Operational workforce requirements and operational time are discussed in Section 2.12. The decommissioning strategy at the end of plant life is outlined in Section 2.13.

2.2 OBJECTIVES OF THE PROJECT

Deckhand has access to long-term mineral sands mining leases including large quantities of monazite. In addition it has secured and stockpiled 6,500 t of monazite concentrates to use as feedstock and has access to other feedstock in anticipation of the construction of the proposed rare earth processing plant. Currumbin Minerals also has current exploration licences for xenotime which would be used if discovered and developed. Accordingly, the objectives of the project are to:

- develop a plant to process monazite (and xenotime if available) in order to extract rare earths and rare earth concentrates;
- provide a reliable supply of good quality rare earth compounds and rare earth concentrates to meet the needs of export and Australian markets. Because of limited local markets it is proposed initially to export 97% of the rare earth products;
- capitalize on existing high demand for rare earth products by processing local ores and utilizing existing infrastructure where possible;
- encourage Australian manufacturers to utilize the rare earth products and to establish related high technology manufacturing industry and business;
- meet all legislative and business requirements that would ensure an environmentally acceptable, technically feasible and financially sound rare earth processing plant.

2.3 SUPPLY OF FEEDSTOCK

Australian monazite is a by-product of mining beach sands for ilmenite, rutile and zircon. At the end of 1984, Australia's demonstrated economic resources of monazite totalled about 216,700 t, some 80% of which was contained in the mineral sands deposits of Western Australia, with the balance in the mineral sands deposits of the east coast. About 50% of the resources on the east coast cannot be mined for environmental reasons (Bureau of Mineral Resources 1987). Total New South Wales resources of monazite available for mining are conservatively estimated at about 20,000 t, and 1,034 t were produced during 1985 (Department of Mineral Resources 1986a). Xenotime production in Australia is much smaller with 46 t produced in 1985 (Bureau of Mineral Resources, pers. comm. 1987). In addition, up to 20 Mt of bastnasite and florencite containing rare earths may be available as part of the Olympic Dam mineralization in South Australia. World resources of the rare earth elements are large and ample for several hundred years at current rates of demand (United States Department of the Interior 1985).

Most of the east coast resources are located in south-east Queensland and north-east New South Wales - the main sources of Deckhand's feedstock. In New South Wales, monazite occurs as a minor constituent of rutile-zircon-ilmenite sands from the north and central coast beaches, in tin concentrates from the New England district and in pegmatitic lodes in the Broken Hill and New England districts. However, only the coastal sources are commercially mined. The proposed rare earth processing plant would be designed to take the existing and anticipated monazite production of the Australian east coast mineral sands producers and is based on a 2,000 t annual throughput of monazite and xenotime concentrates.

Production from all the monazite sources has appropriate mining and environmental clearances from relevant government authorities. Long-term mining leases are also current for all sources of monazite. In addition, rehabilitation of mined areas is a condition of leases granted by the New South Wales Department of Mines. Further major sources of mineral sands presently being developed and re-mined in the Newcastle region of New South Wales would add to the potential production of monazite. However, the proposal would not require the mining of any additional mineral sand areas or other sensitive environments, an action that could conflict with New South Wales government policy on mineral sand mining. In addition, 6,500 t of contained monazite concentrate have been secured and stockpiled by Currumbin Minerals for Deckhand to use as an initial feedstock and buffer. This stockpile is equivalent to more than 3 years' supply of feedstock. Deckhand has access to at least 10 years' supply of feedstock, including the existing stockpile held by Currumbin Minerals, from currently approved east coast mining operations.

Other rare earth feedstock resources are also available from outside the east coast area of Australia if required by the proponent. These resources include possible feedstock from significant heavy mineral deposits being developed in Queensland, Victoria and South Australia. Currumbin Minerals also holds exploration licences in the Kimberley mineral field of Western Australia with potential sources of monazite and xenotime. Tailings containing monazite are also available from Queensland tin producers. In addition, suppliers from Brazil, South Africa, Sri Lanka and China have offered Deckhand supplies of monazite that could be legally imported subject to health and safety requirements. However, the proponent prefers to use local feedstock suppliers and monazite would only be imported if the suppliers of Australian feedstock were unable to meet requirements.

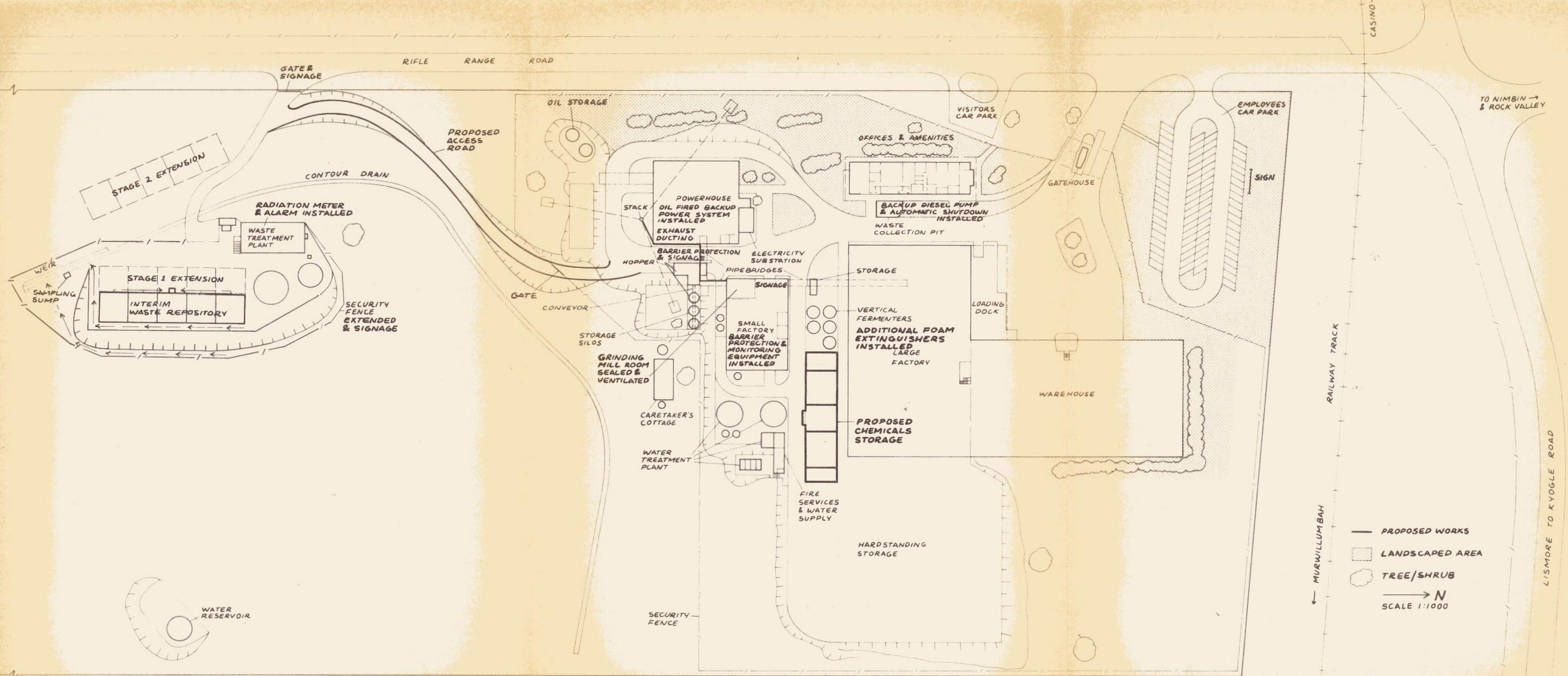


FIGURE 2.1
PLAN OF WORKS REQUIRED FOR THE
PROPOSED RARE EARTH PROCESSING
PLANT

The approximate rare earth oxide composition of Australian east coast monazite is listed in Table 1.1. The monazite typically contains 55% rare earth oxides, 6.6% thorium oxide, and 0.3% uranium oxide with the remainder predominantly phosphate compounds. Xenotime contains the same elements as monazite but with a different distribution and much lower thorium content. As the concentrations and composition of monazite and xenotime vary according to source and location in the orebodies, the feedstock would be blended to maintain relatively consistent production of each rare earth compound.

2.4 TREATMENT PROCESSES

2.4.1 Alternative processes

Individual rare earth metals are produced by the treatment of rare earth mineral concentrates such as monazite, xenotime and bastnasite. Bastnasite has replaced monazite as the world's principal source of rare earths but it is not yet mined in commercial quantities in Australia. The two basic processes for treating monazite and xenotime concentrates (alkaline process and acid process) both separate phosphorus, thorium and uranium from the contained rare earth elements:

Industrial processing of monazite and xenotime concentrates consists initially of digestion in sulphuric acid or sodium hydroxide, separation of the thorium and certain other elements, and subsequent recovery of various mixed rare earth compounds and individual oxides. The sodium hydroxide treatment is preferred because it removes phosphates from monazite more readily than the sulphuric acid process.

In the alkaline process, monazite concentrate is finely ground and reacted with a hot concentrated solution of sodium hydroxide at 140 to 150°C for several hours. Hydroxides of the rare earths and thorium formed in the reaction are insoluble, and trisodium phosphate and excess sodium hydroxide remain in solution. Water is added, and after settling the insoluble hydroxides are recovered by filtration, sodium hydroxide is recycled to digestion, and trisodium phosphate is recovered by crystallisation.

The filtered hydroxides are washed, and the thorium is removed using one of several methods. In one process the precipitated hydroxides are dissolved in nitric or hydrochloric acid, and the thorium hydroxide is selectively precipitated by partial neutralisation of the solution with sodium hydroxide or ammonium hydroxide and filtered.

A second process to remove thorium selectively dissolves the rare earth hydroxides. The precipitated rare earth and thorium hydroxides are mixed with water and brought to a pH of 3.4 by the addition of hydrochloric acid. At this pH the rare earth hydroxides selectively dissolve, forming a rare earth chloride solution. Undissolved thorium hydroxide is removed by filtration and may be heated to produce thorium oxide.

Thorium may also be removed from the rare earths in the aqueous phase by solvent extraction with tri-n-butyl phosphate or certain amine nonaqueous solvents. Amine extractants reportedly function best in sulphate solutions and form a high purity thorium complex.

In the acid process, monazite or xenotime is finely ground and reacted with concentrated sulphuric acid at 200°C. After digesting under controlled conditions of acid concentration and temperature, the rare earth and thorium sulphates thus formed are dissolved in water. Insoluble impurities are separated by filtration. The thorium is precipitated from the solution with ammonia and sodium pyrophosphate. The rare earths are subsequently precipitated as an insoluble double sulphate by reacting with sodium sulphate, or as a rare earth oxalate by reacting with oxalic acid. The double salt can be reacted with sodium hydroxide to form rare earth hydroxide. (United States Department of the Interior 1985 and Department of Science 1986).

Historically, the production of individual rare earths has been difficult because their similar atomic structures give them similar chemical properties. After the acid or alkaline process is applied to the rare earth feedstock, solvent extraction and ion exchange techniques are used by most processors to separate individual rare earth compounds although other non-commercial methods include fractional crystallization, fusion, and volatilization. Although the solvent extraction processes used are efficient, they are complex, involving multiple stages using organic phosphates, acids or amines contacted with aqueous solutions of rare earths. The ion exchange method uses resin columns that eliminate the multiple stages of the solvent extraction method. The actual rare earth elements or metals are usually produced by electrolysis of rare earth chlorides, oxides and fluorides and metallothermic reduction of rare earth compounds.

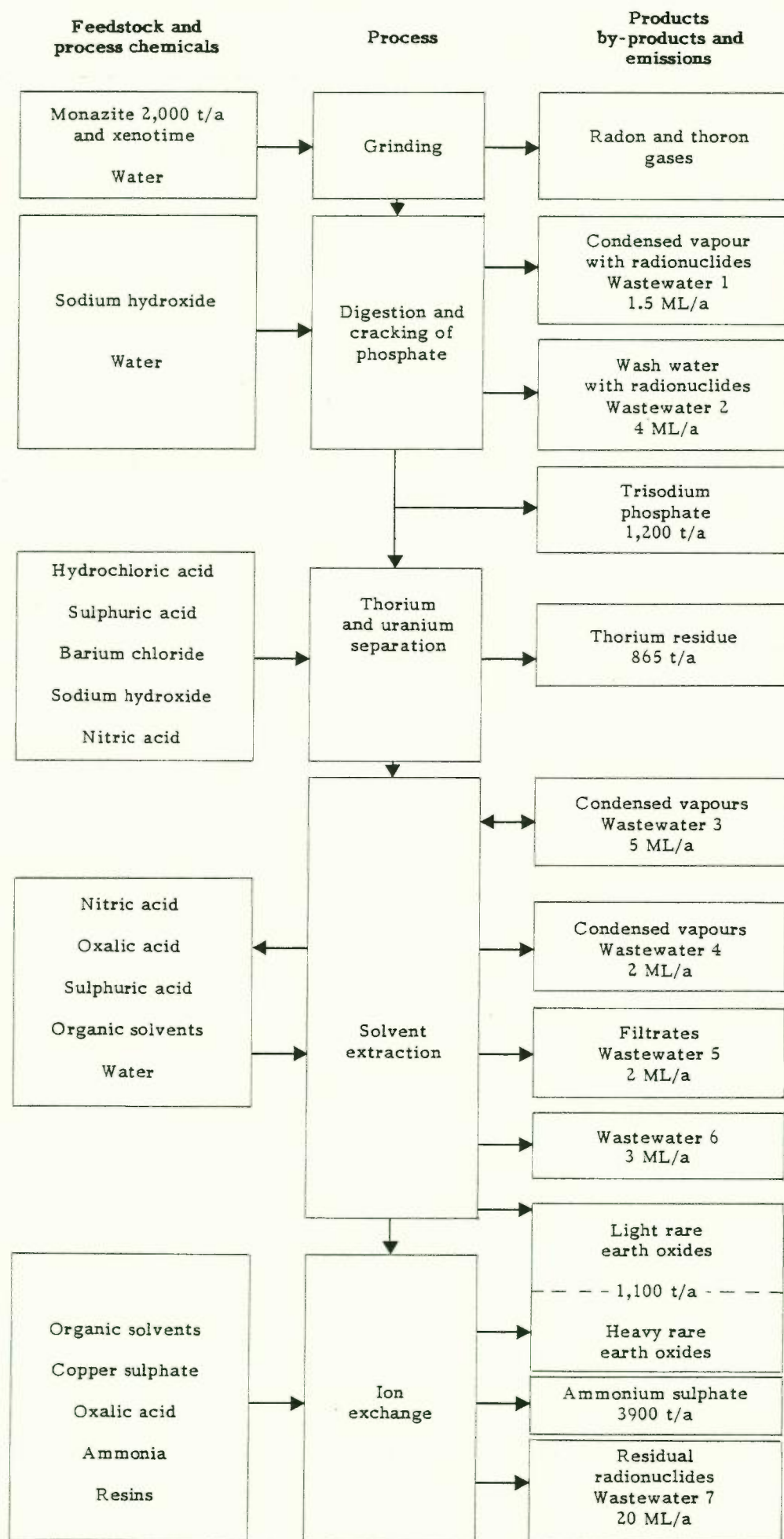
2.4.2 Proposed treatment process

Deckhand would use the more efficient alkaline process in the proposed rare earth processing plant. Approximately 96.5% of the rare earth oxides would be extracted from the monazite and xenotime using the alkaline process. An advantage of this process is that it produces trisodium phosphate and ammonium sulphate as marketable by-products. In addition, the solvent extraction and ion exchange methods would be used in combination to increase the plant's efficiency in extracting rare earth compounds. The sulphuric acid process was rejected because it is less efficient at processing monazite, it produces fewer marketable by-products, and it creates a less favourable working environment than does an alkaline process.

Although this section describes the concepts and general separation techniques that would be used, details of the actual procedures, the sequences of specialized operations, and yields and identities of selected organic solvents remain commercial secrets and have not been discussed, although they would be in accordance with this section. The proposed process is extensively wet and would recover high-purity, heavy rare earth oxides and light rare earth oxides from monazite (and xenotime if available) by initially grinding the feedstock and then applying selected chemicals at the main stages of caustic leaching, acid dissolution, solvent extraction and ion exchange. A conceptual process flowsheet for the proposed plant, which shows the chemical and feedstock inputs, the process and resultant products, by-products and emissions, is shown in Figure 2.2.

Broadly, the proposed process involves firstly breaking down the binding phosphate matrix of the feedstock. The monazite and xenotime are finely ground and then digested in sodium hydroxide, under elevated conditions of temperature and pressure, in an enclosed reactor vessel. This results in the formation of hydroxides of the rare earths and thorium, with associated daughter radionuclides. This stage, commonly referred to as the cracking process, is similar to that used by all the major treatment plants outside Australia.

Figure 2.2 Process flow sheet for the proposed rare earth processing plant



Subsequent steps in the process involve dissolution of the hydroxides and separation of the rare earths from the radioactive components by selective precipitation and filtration. All of the above stages would be undertaken in the small factory. Solvent extraction and ion exchange techniques would then be employed in the large factory to produce a range of rare earth compounds and rare earth concentrate products. The nature of the process allows the treatment to be undertaken in batches, with strict quality control of the products, and permits nonconforming material to be readily reprocessed.

Grinding

The mixed mineral sands would be transported by a totally enclosed screw and bucket conveyor from the receiving hopper to the grinding mill in the small factory where they would be mixed with water and ground, using a ball mill, to an extremely small particle size. This small particle size improves the digestion or cracking of feedstock in the next stage.

Digestion and cracking of phosphate matrix

The ground monazite and xenotime slurry would then be mixed with sodium hydroxide in an enclosed reactor vessel. The reactor is operated under pressure, and is heated by passing steam through a coil or vessel jacket so as to maintain the temperature at around 140°C in order to increase the rate of reaction. The rare earth and thorium phosphates contained within the monazite and xenotime are converted to hydroxides and sodium phosphate after a few hours digestion.

The contents of the reaction vessel would then be diluted with water and the soluble sodium phosphate separated from the insoluble rare earth and thorium hydroxides by filtration. The sodium phosphate liquor would be crystallized and dried. The insoluble rare earths and thorium hydroxides would be dewatered and washed. The washwater would be pumped to the waste treatment plant and the washed filter cake of rare earths and thorium hydroxides would proceed to the thorium and uranium separation stage.

Thorium and uranium separation

The residue from the phosphate filter would contain the insoluble rare earth and thorium hydroxides. The thorium and uranium contents of the original monazite and xenotime ores would also be present. The separation of the rare earths from the radioactive thorium and uranium hydroxides, which would take place in the small factory, is a key part of the process. This separation is achieved by the controlled addition of hydrochloric acid. Rare earth and radium hydroxides are dissolved in the acid and the insoluble thorium and uranium, separated by filtration, are designated 'thorium residue'.

The subsequent addition of sulphuric acid and barium chloride to the rare earth chloride solution would immobilize the radium compounds by causing radium sulphate to be co-precipitated with insoluble barium sulphate. This precipitate would be removed by filtration with the thorium residue. This barium chloride procedure is standard practice for the treatment of radium in solution.

The filtrate from the thorium and uranium filter would be further neutralized with sodium hydroxide to precipitate all the rare earth hydroxides. These would then be filtered and dried, and the cerium would be oxidized from the trivalent to the tetravalent state by placing it in contact with hot air. The air for the dryer would be heated in a steam heated exchanger. The exhaust gas from the

dryer would pass through a filter to remove and recover any particulates prior to its discharge to the atmosphere. The dried cake would then be redissolved in nitric acid to form a rare earth nitrate that formed the feed for the solvent extraction stage of the process.

Solvent extraction

The light and heavy rare earths would then be separated by using a solvent extraction process that is used in a wide range of separation and purification applications. The rare earth nitrate solution would be mixed with an organic solvent in a counter current extraction unit located in the large factory. Cerium would initially be separated, and the non-cerium nitrates would then be concentrated and fed to a second extraction unit. The heavy rare earth nitrates would concentrate in the solvent, while the light rare earth nitrates would remain in the aqueous solution. The aqueous and organic solutions would then be separated by decanting. The aqueous solution of light rare earth nitrates would be pumped to an oxalation stage where nitric acid was recovered and a product containing fused light rare earth oxalate(salt of oxalic acid) was obtained. This oxalate would then be calcined and rare earth oxides produced.

The solvent containing the heavy rare earth nitrates would be fed to a regeneration unit from where the solvent was recovered by the use of sulphuric acid and then returned to the extraction unit. Nitric acid would be recovered from the solution of heavy rare earth sulphates in an evaporation unit.

Ion exchange

The ion exchange separation stage relies on the efficient use of special resins to separate the heavy rare earths. The rare earth sulphate solution would be fed in batches into ion exchange columns located in the large factory. The steps involved in this process include absorption of the rare earths on to the columns, followed by desorption from the resin through complexing the rare earth ions with a chelating agent, and regeneration of the resin using copper sulphate.

When the required quality of rare earths was attained, the chelating agent would be recovered. Oxalic acid would then be added to the solution containing the heavy rare earths to produce a rare earth precipitate. The filtrate would be neutralized by ammonium hydroxide. After filtration, each product would be roasted to produce the final rare earth oxide as a fine powder. Fractionation and purification sections of the ion exchange plant would also produce ammonium sulphate as a by-product.

2.5 PROCESS CHEMICAL REQUIREMENTS

The rare earth processing plant would require mainly liquid process chemicals to extract the rare earths from the monazite and xenotime. The annual feedstock design requirement for the plant totals 18,000 t. Although individual chemical requirements cannot be disclosed for commercial reasons, Table 2.1 shows the quantities of chemicals that would be stored on site. Figure 2.3 shows a plan, section and elevation of the proposed bunding to be constructed adjacent to the vertical fermenters for chemical storage in addition to existing storage facilities for water treatment chemicals. The design of the bunding is discussed in Section 6.10.2.

These process chemicals would be purchased from Australian suppliers in Brisbane and Sydney who would act as agents for overseas suppliers when local supplies were not available.

Table 2.1 Process chemical requirements and storage

Chemical (concentration)	On-site storage (t)
Sodium hydroxide (50%)	110
Hydrochloric acid (33%)	75
Sulphuric acid (industrial)	60
Nitric acid (58%)	80
Ammonia (25%)	120
Oxalic acid (industrial)	80
Hydrogen peroxide (15%)	25
Others (water treatment, cleaning and trade waste chemicals, barium chloride, organic solvents, benzene, copper sulphate)	150
Total	700

2.6 PRODUCTS AND BY-PRODUCTS

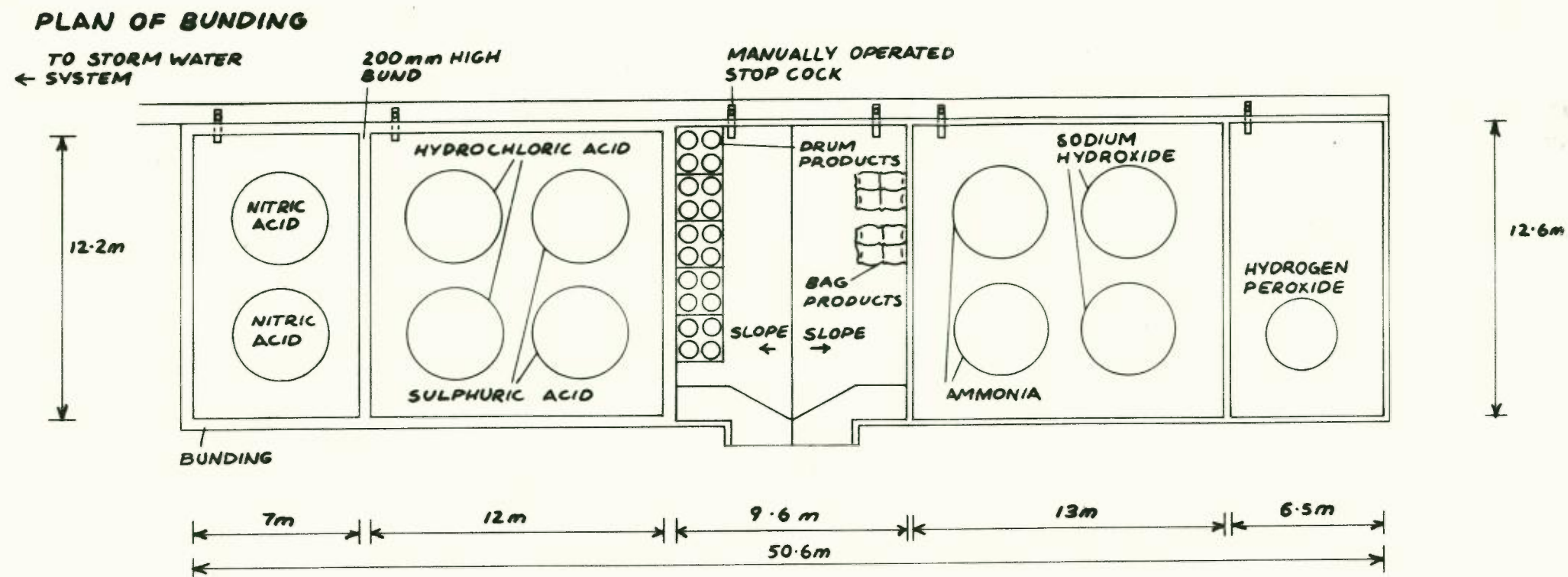
2.6.1 Products

The rare earth products would be produced in a dry fine powder form and are non-toxic and non-radioactive. The products would include a variety of rare earths as individual or mixed compounds and rare earth concentrates of high purity. As the process is flexible, and would be undertaken in batches, the exact nature and mix of products would be dictated by market requirements at any given time. Most commercial rare earth products contain individual elements in about the same ratio as the treated ore shown in Table 1.1.

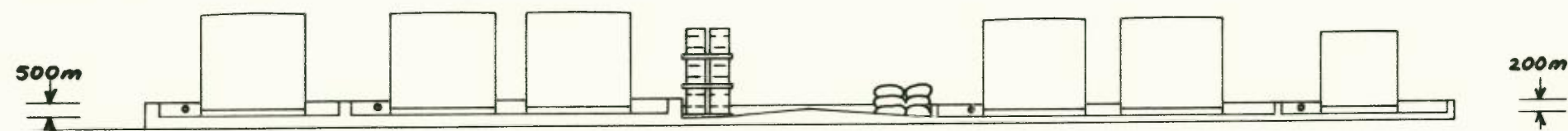
Assuming the monazite feedstock would have a rare earth oxide content of 55%, approximately 1,100 t/a of light rare earth oxides and heavy rare earth oxides would be produced. Compounds for almost all of the individual rare earths are available as oxides, acetates, carbonates, chlorides, fluorides, nitrates, oxalates and sulphates, and would be produced according to customer requirements and market conditions. The rare earth processing plant might produce some individual rare earth metals or a mixture of rare earth metals known as mischmetal, depending on market development.

2.6.2 By-products

Trisodium phosphate is a marketable by-product that results from the feedstock digestion and cracking stage of the process. Although approximately 1,200 t/a would be produced, the by-product would not be processed further on site. The trisodium phosphate would not exhibit residual activity at a level that could be classified as radioactive according to the Radioactive Substances Regulations (1959) and this would be tested during commissioning of the plant. Deckhand would market the trisodium phosphate separately for use in the manufacture of products such as industrial detergents.



SECTION



LOCATION PLAN SCALE 1:1000

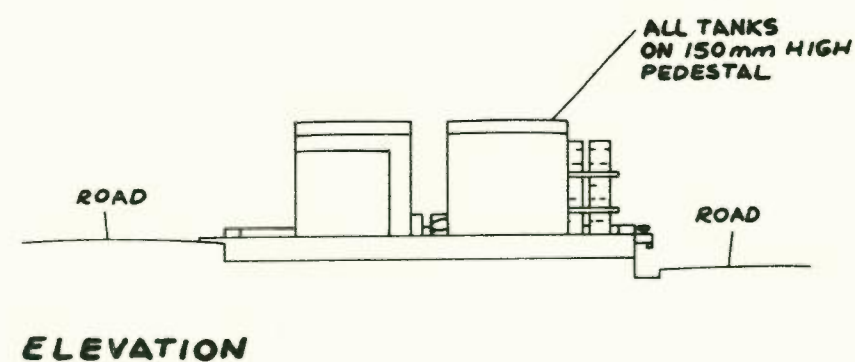
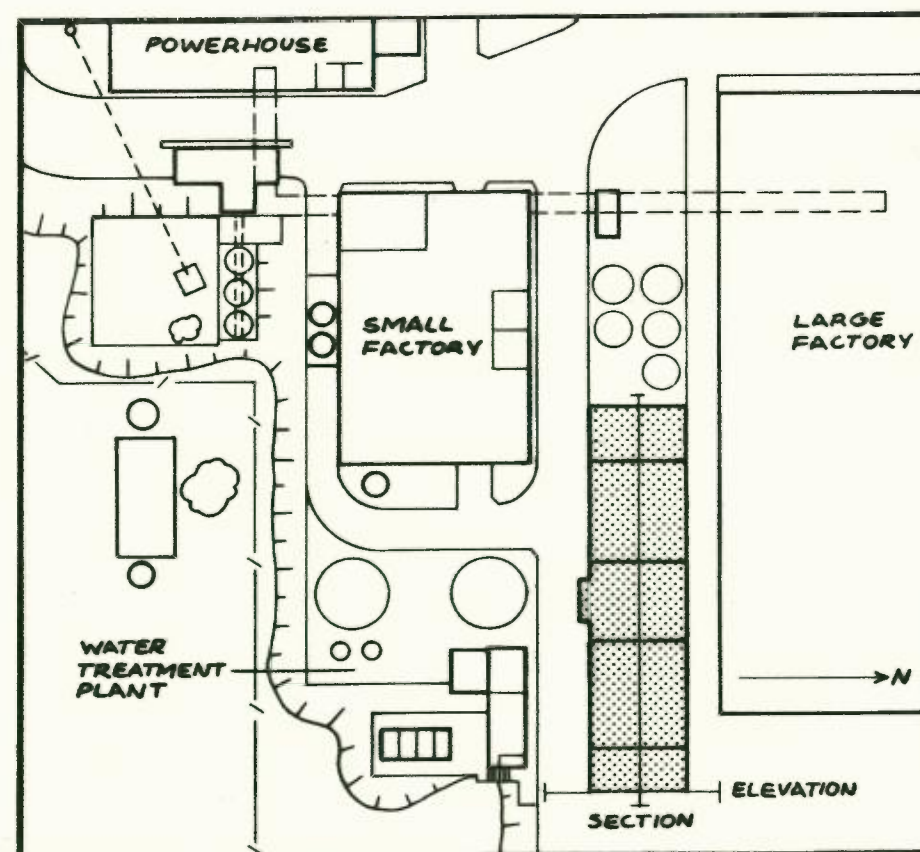


FIGURE 2.3
PROPOSED CHEMICALS STORAGE
BUNDING PLAN, SECTION AND
ELEVATION
SCALE 1:250

Another marketable by-product, ammonium sulphate, results from the ion exchange plant. Depending on intermediate rare earth concentrate products marketed, up to 3,900 t/a would be produced but would not be processed further on site. The ammonium sulphate would be marketed as a product for use in the manufacture of fertilizers.

Another by-product would be the 865 t/a of thorium residue produced during the thorium and uranium separation stage of the process. The thorium residue (in gel form) would be approximately 45% solids and 55% water by weight, and would be expected to have an activity level of 3,750 Bq/t. The extracted thorium and uranium hydroxides (155 t/a) represent over 99.99% of the original thorium and uranium contained in the annual feedstock. The pH of the process would be adjusted to ensure this high rate of extraction even though it would result in some loss of rare earths in the residue. The approximate composition and annual production of the thorium residue is shown in Table 2.2.

Table 2.2 Composition and production of thorium residue

Compound	Annual production (t)
Thorium hydroxide	150
Monazite (unreacted)	10
Uranium hydroxide	5
Rare earth chloride and hydroxide	40
Water	480
Others (mainly mineral sand impurities and barium sulphate precipitate)	180
Total	865

It is possible to process the thorium residue further in order to extract useful by-products, including thorium hydroxide and uranium hydroxide. The market for the thorium residue is being explored by Deckhand. Thorium compounds are used in incandescent gas mantles, metal alloys, and in ceramics and glazing industries.

2.7 PROCESS EMISSIONS

The main emissions from the process are the process wastewater streams (which would include radionuclides and other solid loadings); emissions to the atmosphere from the boilers, process exhaust gas and process evaporation loss; and the gaseous radionuclides, radon and thoron and their daughters. The emissions produced at each step in the process are shown in Figure 2.2 and are also detailed below.

2.7.1 Grinding

At the grinding stage, the feedstock would initially be discharged into the hopper under sealed conditions and conveyed to the grinding mill in the small factory. Any radioactive emissions arising from the generation of dust from feedstock material in the hopper would be limited to the secular equilibrium quantities in the ores and would be expected to have an activity level of 7.5×10^5 Bq/kg of ore. A dust collector would be provided on the screw conveyor to reduce dust emissions. The use of wet grinding would eliminate the possibility of further dust emissions, and the mill design would ensure that the process was also watertight during the grinding operation.

2.7.2 Digestion and cracking of phosphate matrix

During the cracking and phosphate removal stage, the emission of the gaseous radionuclides, radon (radon-222) and thoron (radon-220), and their daughters to the atmosphere would be restricted by cooling and condensing the steam in an enclosed condenser. Since both isotopes are highly soluble in water, the radioactive contamination would be mostly contained within the condensate. This condensate, designated wastewater 1, would have a volume of 1.5 ML/a. At the thorium and uranium separation stage the washwater from the filter has been designated wastewater 2, with a volume of 4 ML/a. Because of limitations on filtration efficiency, wastewater 2 is expected to contain some fine grain particulate radionuclides. An assessment of the concentrations of these radionuclides, based on previous bench scale tests, is shown in Table 2.3.

Table 2.3 Wastewater 2 radionuclide concentrations

Radionuclide	Concentration
Uranium-238	4.8×10^5 Bq/m ³
Uranium-234	4.8×10^5 Bq/m ³
Thorium-232	1.2×10^4 Bq/m ³
Thorium-230	8.4×10^2 Bq/m ³
Radium-226	1.1×10^2 Bq/m ³

Source: Kinhill Stearns (1985)

2.7.3 Thorium and uranium separation

Also at the thorium and uranium separation stage, special steps would be taken to immobilize the radium isotopes that are decay products of the thorium and uranium. The maximum possible quantities of radium isotopes would be limited to the secular equilibrium quantities in the original monazite and xenotime ores (Table 2.4).

Table 2.4 Radium quantities at thorium and uranium separation stage

Radionuclide	Maximum quantity
Radium-224	8.0×10^{-5} g/a
Radium-228	6.0×10^{-2} g/a
Radium-226	1.1 g/a

Source: Kinhill Stearns (1985)

2.7.4 Solvent extraction

The filtrate from the thorium and uranium filter would contain only minor amounts of radionuclide contamination. At the solvent extraction stage, vapour from the aqueous solution of light rare earth nitrates in the evaporation unit would be condensed; this condensate, which would be reused in the process, has been designated wastewater 3. The wastewater that would result from the solution of heavy rare earth sulphates in the evaporation unit, following extraction of the nitric acid, has been designated wastewater 4. Wastewaters 3 and 4 would have volumes of 5 ML/a and 2 ML/a respectively. Two other wastewater streams would also be produced at the solvent extraction stage. A wastewater volume of 2 ML/a from the filtration of the heavy rare earths has been designated wastewater 5, and 3 ML/a of wastewater resulting from washing the filter has been designated wastewater 6.

2.7.5 Ion exchange

At the ion exchange stage, the filtrate from the rare earth filter would be neutralized by calcium hydroxide, thus producing an insoluble calcium sulphate precipitate. Washing of filters results in wastewaters designated wastewater 7. Wastewater 7 (20 ML/a) is expected to contain residual radionuclides at the concentrations shown in Table 2.5.

Table 2.5 Wastewater 7 radionuclide concentrations

Radionuclide	Concentration
Thorium-232	under 4.07×10^3 Bq/m ³
Radium-228	0.43×10^3 Bq/m ³
Uranium-238	0.43×10^3 Bq/m ³
Radium-226	0.4×10^3 Bq/m ³
Lead-210	0.6×10^3 Bq/m ³

Source: Kinhill Stearns (1985)

2.7.6 Loadings of wastewater streams

Some of the wastewater streams would contain salts from process reactions and residual quantities of alkalis or acids used in processing. The main salts that would be present in the total wastewater stream and their approximate quantities are shown in Table 2.6.

Table 2.6 Loadings of wastewaters

Compound - chemical formula	Annual quantities (t)
Sodium chloride - NaCl	2,000
Ammonium sulphate - $(\text{NH}_4)_2\text{SO}_4$	360
Sodium orthophosphate - Na_3OPO_4	10
Total	2,370

2.7.7 Atmospheric emissions

The gaseous radionuclides that would be produced during the grinding stage of the process are discussed in Section 2.7.1. Other atmospheric emissions from the process would include boiler emissions and process exhaust gas composed of water vapour and carbon dioxide of 4,600 t/a and process water evaporation loss of 9,800 t/a.

2.7.8 Total wastewater flows

The total wastewater flows of 320 ML/a (Figure 2.4) would include 32.5 ML/a used in the process, with the remainder being used as dilution water. Wastewater 3 (5 ML/a) would be pumped to the water treatment plant for reuse in the process. All other wastewaters would be pumped to the waste treatment plant for treatment and dilution.

2.8 UTILITIES AND INFRASTRUCTURE

To become operational, the proposed rare earth processing plant would require inputs of energy and water, and the provision of utilities, services and facilities. The essential utilities and infrastructure, already in place as part of the site development for the former brewery, are described in Section 5.2.

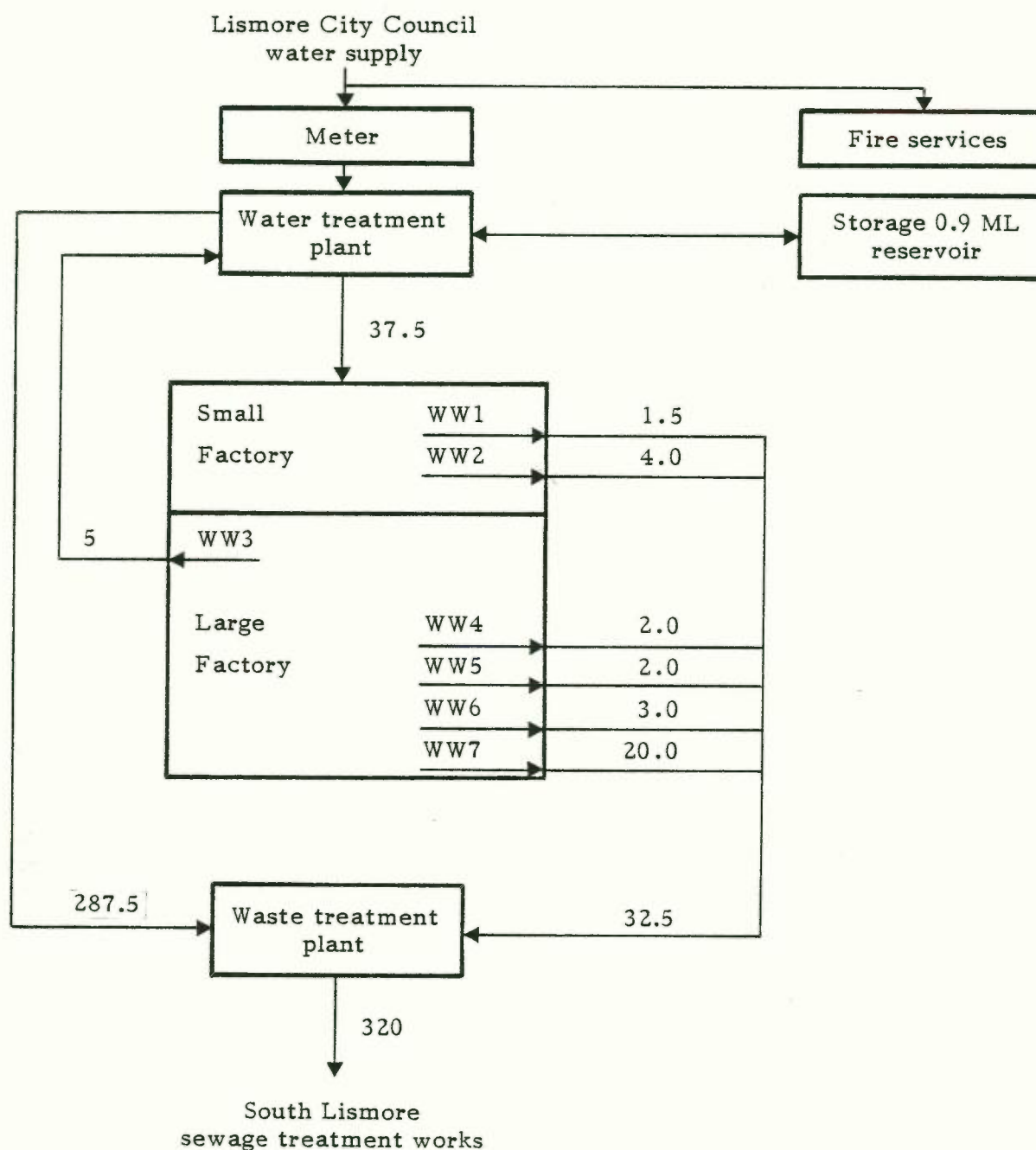
2.8.1 Electricity

Electricity would be provided by the Northern Rivers County Council via an existing 415 V underground line on site leading to the substation abutting the powerhouse. Electricity would be the main source of power and the expected annual average electricity consumption is $2-3 \times 10^6$ kW.h. This is less than previously supplied to the brewery by the Northern Rivers County Council.

2.8.2 Water

Water would be supplied by Lismore City Council via the existing metered system to the water treatment plant and an unmetered branch for fire fighting. Metered water consumption is expected to be 320 ML/a of which 32.5 ML/a would be used in the process, 5 ML/a would be recycled, and 287.5 ML/a would be used in the waste treatment plant for diluting the wastewater streams. Lismore City Council has indicated that it can supply the rare earth processing plant water requirements. A water main of 788 ML/a capacity presently serves the site.

Figure 2.4 Proposed rare earth processing plant process water flows



Legend

5 Water quantity 5 ML/a

WW Wastewater stream

2.8.3 Fuel oil

Fuel oil would be supplied to the two fuel oil storage tanks located on site. The storage tanks each have a capacity of 125 t and annual requirements are expected to be 3,900 t/a. The two oil-fired boilers in the powerhouse would generate steam for the process and a back-up oil-fired power system would also be installed.

2.8.4 Waste treatment, sewerage and drainage systems

The systems already installed on site have enough capacity to accommodate site runoff and expected flows from the rare earth processing plant. Waste from the treatment plant would discharge into the sewerage system leading to Lismore City Council's pump station and thence on to South Lismore sewage treatment works, 3 km south-east of the site, for treatment before its discharge into Hollingsworth Creek. The drainage system would collect site run off and discharge on to adjacent public lands mainly via Lismore City Council drains under Rifle Range Road.

2.8.5 Fire fighting

These facilities are described in Section 5.2. Hand held foam extinguishers would be located at strategic points in all buildings to supplement the existing automatic sprinkler, ring main hydrants and hosereel systems.

2.8.6 Communications

External communications would be by existing telephone and telex systems. Internal communications would be by existing internal public address, telephone and alarm systems. External and internal transport connections would be via existing external and internal paved roads and one internal access road to be constructed.

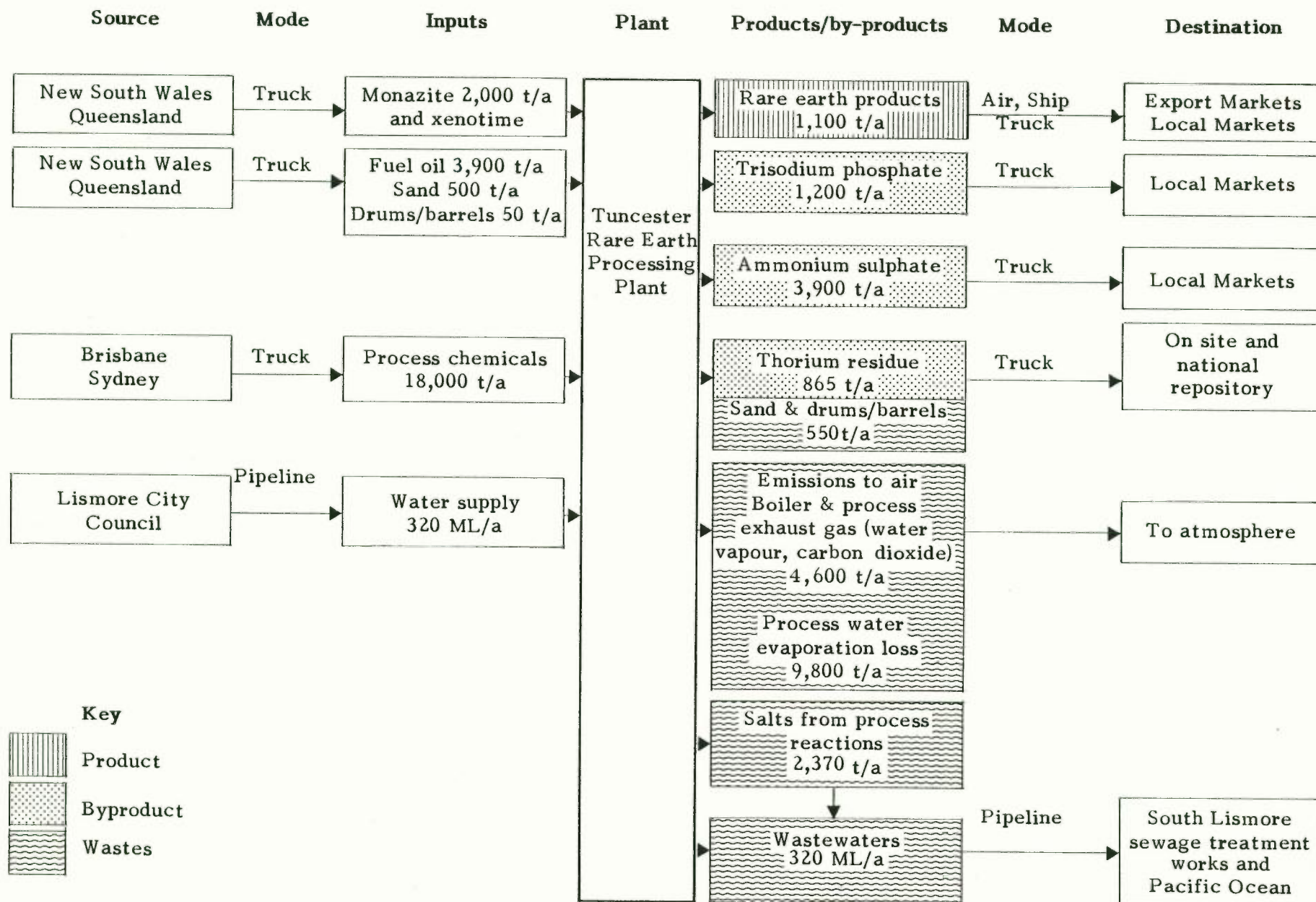
2.8.7 Other infrastructure

This would include a first aid station already provided in the administration and office building, refrigeration and compressed air systems, internal and external lighting systems and a 2.3 m high security fence surrounding the developed portions of the site.

2.9 TRANSPORT, HANDLING AND STORAGE

The amount of material to be transported to the site annually would be about 24,450 t, composed of 2,000 t of feedstock, 18,000 t of process chemicals (including water component), 3,900 t of fuel oil, 500 t of sand and 50 t of drums or barrels. These figures exclude water supply of 320,000 t (320 ML). Road transport would provide the main links between the plant and the flow of materials. Transport of materials within the plant would be by machine, truck, hand, pipeline and conveyor. The amount of material to be transported from the site annually (excluding wastewaters and air emissions) would be about 7,065 t composed of 1,100 t of rare earth products, 1,200 t of trisodium phosphate, 3,900 t of ammonium sulphate and eventually 865 t of thorium residue. Road transport would also be the main mode of transporting materials from the plant. The relationship between the movements of materials to and from the plant is shown in Figure 2.5.

Figure 2.5 Proposed rare earth processing plant material flows



All of the feedstock would be transported to the site by truck along designated main roads and State highways in accordance with the Commonwealth Code of Practice for the Safe Transport of Radioactive Substances, 1982. The actual routes have not been specified as this would disclose the sources of feedstock to the proponent's competitors. The feedstock would be contained in 2 t kibbles, 1.5-2 t bulker bags and as bulk loads. Approximately 50 t of feedstock would be required each week. The monazite and xeontime would be discharged by gravity into a receiver on a screw conveyor. The discharge of feedstock from kibbles, bulker bags or bulk loads would be via a completely sealed entry using protective skirting as a funnel from the container to the screw conveyor to prevent dust dispersion. The screw conveyor would feed a fully enclosed bucket conveyor that travels to the storage silos and then into a storage bin in the small factory. Only the westernmost silo would be used for transit of the feedstock to the small factory. Up to 70 t of feedstock would be stored on site in the receiving hopper.

The process chemicals would be transported from Brisbane and Sydney via designated main roads and State highways by truck tankers or bulk containers, and in accordance with Commonwealth, Queensland and New South Wales transport regulations. The chemicals would be stored in tanks, drums and bags depending on the type of chemical and whether it was in liquid, solid or crystal form, and in accordance with New South Wales regulations. A concrete bund to be constructed on the concrete platform located to the east of the vertical fermenters would serve as a chemicals storage area in addition to the water treatment chemicals storage area located east of the small factory. On site, the chemicals would be transported by pipeline and machine. The liquid feedstock would be transported between the small and large factories by pipeline over the existing pipe bridges.

The rare earth products would be in a powder form and would initially be contained in product storage bins in the warehouse. The product would then be weighed and packed in plastic lined cans, drums and multiwall paper or plastic bags depending on the customer's preference. All packaging would be to approved export standard and, because of the valuable contents, would be secure. The size of packing containers would also vary according to customers' needs, which would determine whether handling is by hand or machine. A common packing method is expected to be drums and plastic bags stacked on a pallet and shrink-wrapped with plastic film. Approximately one week's rare earth output (25 t) would be stored on site in the warehouse before dispatch. Ninety-seven per cent of the final product would be transported by truck along designated main roads and State highways in containers to either Brisbane or Sydney seaports or airports for transport to export markets in Japan, Europe and the USA. Three per cent would be transported within Australia by road or air depending on domestic customer preferences. The split between export and local markets, and hence methods of packaging, handling and transport, is expected to change in the future as associated rare earth manufacturing industries develop in Australia.

The trisodium phosphate by-product, which would be in a powder form, would be packed in bags or cans for weekly dispatch to customers by road. The ammonium sulphate would be in granular form and would be packed in bags for dispatch to customers by road. The fuel oil would be delivered by road tanker to the two storage tanks on site and would be transported to the powerhouse by pipeline.

The thorium residue would be in a gel form and would be packed in 82 L stainless steel barrels or strengthened 205 L steel drums with the openings sealed by remote control. The barrels or drums would be transported by truck to the small factory for filling then by truck or crane truck along the proposed internal

access road to the proposed interim waste repository. Surplus drums or barrels would be stored on the hardstanding storage area. Handling of the barrels or drums at the interim waste repository would be by overhead travelling crane with monorail hoist and roving pendant. Packing sand, to provide stacking stability for the barrels or drums, would be delivered directly to the interim waste repository by truck as required. When the thorium residue was transported to either the national repository or to markets, transport would be by road in accordance with Commonwealth and State regulations. Solid wastes normally accepted by a rubbish tip would be transported by truck to Lismore City Council's rubbish tip. The wastewaters would be transported by existing pipelines to South Lismore sewage treatment works for treatment before their eventual discharge to the Pacific Ocean via Hollingsworth Creek, Wilsons River and Richmond River.

2.10 WASTE DISPOSAL

The wastes from the proposed rare earth processing plant would include feedstock dust and gas emissions, wastewater streams, thorium residues and solid and liquid wastes such as garbage, sullage, sewage, and boiler effluents normally associated with industrial activity. All of these wastes, except the thorium residue, could be dispersed into the environment because of the small quantities of radioactivity contained in them and/or their low toxicity (refer to Chapter 6). Although thorium residue is a low-level radioactive waste it requires containment to ensure longer term isolation from the biosphere, so that any release of radioactive material to the environment occurs at an acceptably low rate (refer to Section 6.8).

2.10.1 Emissions to atmosphere

The dust emissions from the feedstock would be collected in a large dust extractor and collection bin attached to the screw conveyor between the receiving hopper storage bin and storage silos. The dust emissions are expected to be minor and the dusts collected in the collection bin would be returned to the process in a controlled manner.

Radon and thoron gases emission during the grinding and cracking stages of the process would be minimized through the use of a totally wet process and sealed mill and digestion equipment and machinery. The grinding mill part of the small factory would also be sealed and machinery that would provide twenty changes of air per hour would be installed. An exhaust duct to be installed on the existing pipe bridges would extract air and gases from the grinding mill area and feed them into the 52 m high stack adjacent to the powerhouse from where they would be released into the atmosphere. However, most of the radon and thoron gases and their radioisotope daughters would be contained within wastewaters.

Gases from the oil fired boilers would be discharged and dispersed into the atmosphere via the existing 52 m high stack.

2.10.2 Wastewater disposal

A number of disposal options were considered for the wastewaters. Evaporation ponds were not feasible because of the large area of land required. Spray

irrigation was also considered unsuitable because the surrounding area has adequate rainfall to sustain existing agricultural land uses. The trucking of wastewaters to suitable evaporation areas off site was uneconomical. Reverse osmosis treatment of wastewaters using proven high technology filters was considered uneconomical for all the wastewaters, but would be used to recycle 5 ML/a of water within the plant. The selected option would include collection of wastewaters on site, treatment and dilution to meet legislative and Council requirements and discharge to the sewer.

The 32.5 ML/a of wastewater and offices and amenities sullage and sewage would be discharged into the on-site waste collection system for treatment and dilution in the site's waste treatment plant. The 320 ML/a of treated and diluted wastewater from the waste treatment plant would be discharged to the South Lismore sewage treatment works according to New South Wales Government and Lismore City Council requirements. Treated effluent from the South Lismore sewage treatment works is discharged into Wilsons River via Hollingsworth Creek headwaters. The effluent is further diluted and mixed via the Richmond River waters before its final discharge into the Pacific Ocean.

2.10.3 Thorium residue

A number of disposal options for the thorium residue were also considered, some of which are still being pursued by the proponent. Under the Commonwealth Environment Protection (Sea Dumping) Act 1981 the dumping or incineration of radioactive materials at sea is prohibited; this option would not therefore be possible. Australia also ratified the 'Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter' in 1985 which prohibits the dumping of radioactive waste at sea. Relocation of the residue at the feedstock source was rejected on environmental grounds. Mine shaft disposal was considered and temporarily abandoned because of non-acceptance of the residue by the mine owners. Disposal in the numerous disused basalt quarries around Lismore was considered and rejected because of possible environmental problems and time delays. Disposal with the Australian Nuclear Science and Technology Organisation at Lucas Heights was not possible because it has not accepted radioactive wastes since 1977. Disposal at municipal rubbish tips by diluting with other solid wastes to meet specified standards was impracticable because of the volume of other wastes required for mixing with the residue.

The selected option would involve on site storage of the residue in 82 L stainless steel barrels or 205 L strengthened steel drums stacked and packed in sand in a reinforced concrete waste repository. This would be an interim measure until a national repository was established or the residue was purchased by a user of the by-product. The Commonwealth-State Consultative Committee on The Management of Radioactive Wastes Arising from the Medical, Industrial and Research Use of Radionuclides has agreed in principle to establish shallow ground burial sites as waste repositories for low-level radioactive wastes (Commonwealth-State Consultative Committee 1985).

A plan, section and elevations of the interim waste repository is shown in Figure 2.6 and has been designed initially to accommodate 3 1/3 years storage of the residue. However, the repository would be extended if necessary to fit in with the proposed timing of the national repository or any market developments. The on-site repository has been designed to allow easy recovery of the barrels or drums that are also suitable for transport when required.

If a national repository were not made available within 3 years' operation of the proposed rare earth processing plant, or if the residue were not sold, then the

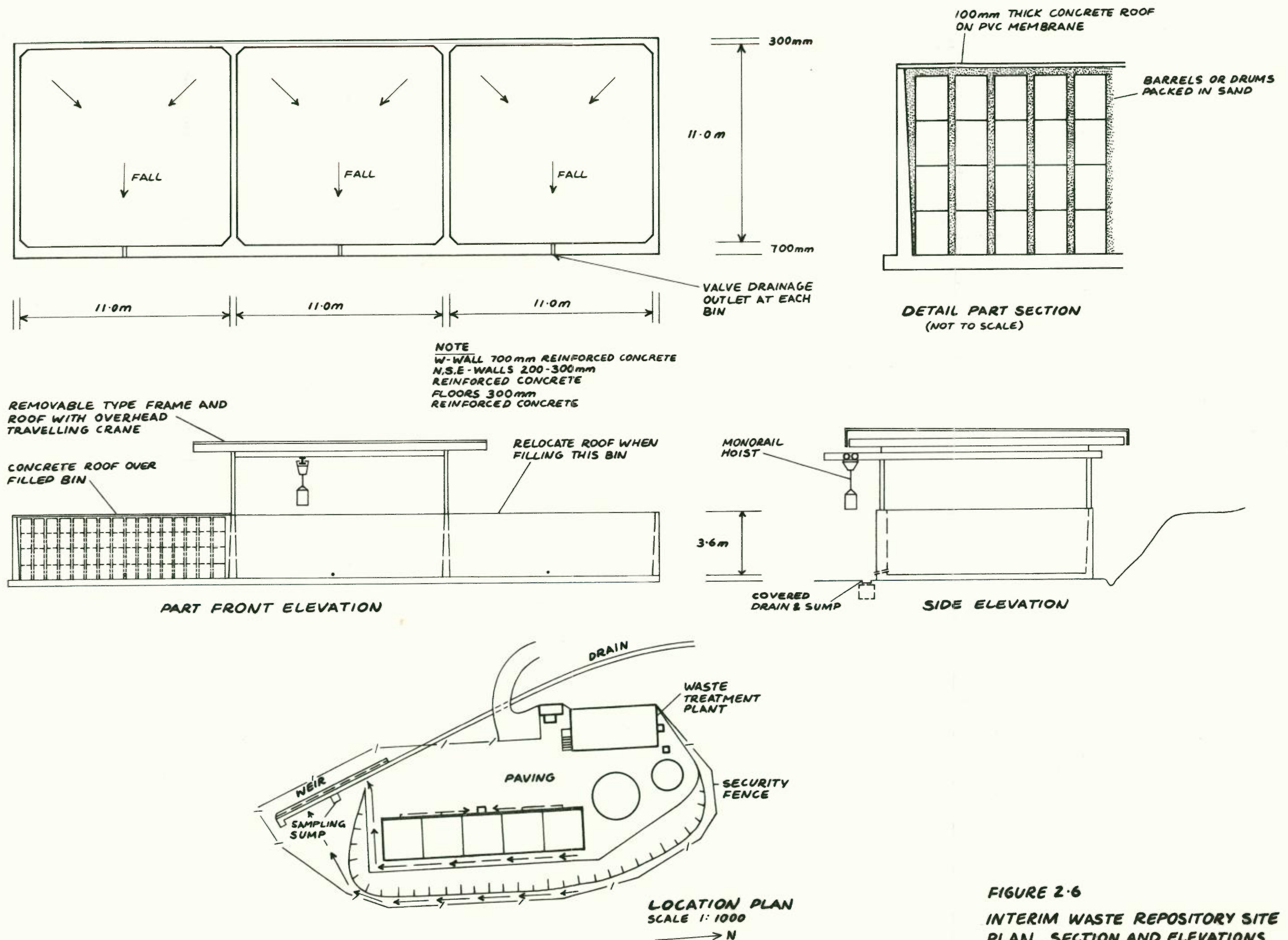


FIGURE 2.6

INTERIM WASTE REPOSITORY SITE
PLAN, SECTION AND ELEVATIONS
SCALE 1:200

proponent would extend the proposed interim on-site waste repository in two stages as shown in Figure 2.1. The stage one extension would replicate the proposed interim waste repository immediately west of the proposed repository. The drainage system would be relocated around both the proposed repository and the stage one extension. If a national repository were not available after 6 years' operation of the proposed rare earth processing plant, or if the residue were not sold, then the proponent would construct a stage two extension of the proposed repository as outlined in Figure 2.1. This stage two extension would have separate access off the existing waste treatment plant access road with protective security fence, signage and drainage system. The stage one and two extensions would be of similar construction to the interim waste repository shown in Figure 2.6 (except that the stage two extension would have 800 mm thick concrete walls) and would each accommodate 3 1/3 years supply of thorium residue as required. The interim waste repository and stage one and two extensions would accommodate 10 years' supply of thorium residue in total if required. If a national repository were not available after ten years operation of the proposed rare earth processing plant, or if the residue were not sold, and the proponent considered another ten years operation was economic then a further interim waste repository would be established on site. The interim waste repository would only store thorium residue produced in the proposed plant and would not accept any other radioactive or hazardous wastes from other sources.

2.10.4 Solid wastes

Solid wastes such as paper, packing material, metal and other scraps normally generated by offices and industry would be disposed of at the Lismore rubbish tip.

2.11 PLANT REFURBISHMENT AND COMMISSIONING

The proponent has programmed plant refurbishment to commence immediately following approval of the development application and necessary licences and permits in order to have rare earth products available in late 1987 or early 1988. In order to become operational, the rare earth processing plant would require expenditure of \$7 million on land, buildings, refurbishment and minor works, plant procurement and installation. Twenty construction and professional workers would be required over the 3 month refurbishment period to install the rare earth processing plant and complete works including installation of barriers, monitoring equipment and other safeguards within the plant, a ventilation system in the grinding mill area, exhaust ducting between the small factory and powerhouse, and surge bins, and to seal the grinding mill room and construct the interim waste repository, internal access road and chemical storage bund. However, the majority of the expenditure would be spent on procurement and installation of equipment and machinery for the actual rare earth processing plant as the site is fully developed and has most of the buildings and infrastructure appropriate to house the plant. The only equipment yet to be dismantled and removed from the plant are the five vertical fermenters (to be removed within 2 years) and miscellaneous smaller items. The refurbishment and construction works would be undertaken by subcontractors who would be responsible for their own labour recruitment (expected to be from the Lismore region). Deckhand would undertake the plant procurement and would co-ordinate the construction and installation works from its corporate office at Currumbin and the offices on site.

2.12 OPERATIONS

The plant would employ up to twenty people full time for plant operations. These people would need to have a range of technical and trade skills, and it is expected that the majority of them would reside in the Lismore region.

The plant would operate on three 8 hour shifts, 7 days a week, 46 weeks a year. Total operating hours would be 7,728 hours a year or 88% of the available time. The plant would not be expected to produce for the equivalent of 6 weeks over the Christmas, New Year holiday period and during annual maintenance and refurbishment periods.

2.13 DECOMMISSIONING

The project has been evaluated by Deckhand on the basis of a 10 year economic life. However, the project could operate for at least 20 years if feedstock could be supplied from local or overseas sources and if local and export markets for rare earth products developed further. Upon decommissioning of the plant, the equipment would be dismantled, decontaminated and removed. The drums or barrels containing the thorium residue would be transported by road to the national waste repository. If required the packing sand would also be transported by road to the national waste repository. Decontamination of the interim waste repository would be undertaken under the direction of the New South Wales Department of Health so that the repository was available for future use as a storage facility. The site would be left clean, with radiation levels being restored as close as possible to pre-operational levels, and in a state suitable for another industrial use and in a manner acceptable to the authorities at the time.

Uranium and thorium decay chains



alpha particle to reach a more stable state. An alpha particle consists of two protons and two neutrons bound closely together, and is actually the nucleus of a helium atom. In the process of emitting an alpha particle, the unstable nucleus loses two protons and so changes to the nucleus of a different element two steps lower in the table of elements. Alpha particles are generally emitted by heavy elements such as uranium, thorium and radium.

Beta radioactivity involves the emission of beta radiation which consists of energetic electrons and positrons (the positively charged equivalent of the electron). The process is quite different from alpha radioactivity because a neutron spontaneously changes into a proton with electron emission or a proton to a neutron with positron emission from the nucleus. The total electric charge in the process must remain the same. The atom which results becomes one belonging to an element one higher in the table of elements when an electron is emitted, or one lower on positron emission.

In both alpha and beta radioactivity, the unstable nucleus releases energy to reach a more stable state through the emission of alpha or beta particles. These emissions often do not leave the nucleus in the most stable state but the residual energy is not enough to cause further particle emission. The most probable event in this circumstance is the release of energy in the form of gamma rays. Gamma rays are high energy electromagnetic radiation, the same form of energy as X-rays and also the more familiar light rays and radio waves. Emission of gamma radiation does not involve any change in the number of protons and neutrons. Table 3.1 summarizes the ability of the different types of radiation to penetrate materials.

Table 3.1 Penetrating ability of radiation

Type	Composition	Interaction with materials
Alpha	2 protons, 2 neutrons (positively charged helium nucleus)	Will just penetrate human skin, stopped by a sheet of paper
Beta	Electron (negatively charged particle)	Passes through about 1 cm of flesh, stopped by thin sheet of aluminium
Gamma	Electromagnetic radiation (no charge, very energetic)	Passes through human body, but absorbed by 1 m of concrete
X-ray	Electromagnetic radiation (no charge, energetic)	Less penetrating than gamma rays, but still passes through human flesh. Absorbed by lead sheet
Neutron	Neutron (uncharged particle)	Passes through human flesh. Stopped by 1m of water

Source: Slatyer (1984)

Radiation arises from a range of natural sources such as the sun and outer space, from naturally occurring radioactive isotopes in the atmosphere, rocks and soil, and in rivers and oceans. Radiation from the sun and space (cosmic rays) and radioactive atoms in all of the matter on earth produce a naturally occurring level of radiation which varies from place to place and is referred to as background radiation. In addition to this natural background radiation, people

CHAPTER 3

ENVIRONMENTAL ISSUES AND RADIATION

3.1 ENVIRONMENTAL ISSUES

This section outlines the environmental issues associated with development and operation of the proposed rare earth processing plant described in Chapter 2. The environmental issues can be grouped into matters related to the direct effects of construction such as site use and clearance; the types, characteristics and treatment of wastes and emissions and their effects on the receiving environment; infrastructure requirements including transport, water supply and energy; indirect effects such as land use and planning provisions, visual amenity and socio-economic impacts; decommissioning of the plant; and associated radiation matters involving health and safety for workers and the public. As most of the site has been developed with modern buildings, facilities and infrastructure, and only minor internal refurbishment and external works would be necessary to accommodate the proposed plant, the direct and indirect effects of construction and further development of the site and infrastructure requirements would not involve any major adverse environmental effects. These direct and indirect effects and infrastructure and energy requirements are addressed in Sections 6.2 to 6.6.

The source of the feedstock for the plant would not involve any additional environmental effects as Deckhand, through Currumbin Minerals, has existing long-term legal mining leases enabling it to mine mineral sands, including monazite, in a number of locations. These areas are all rehabilitated after mining in accordance with the conditions set out in the leases. The end use of the rare earth products and concentrates is not considered an environmental issue either, as they have peaceful and beneficial uses in the development of high technology products.

The main environmental issues relate to the operation and decommissioning of the rare earth processing plant, associated radiation protection for the workers, public health, transport of process chemicals and transport and disposal of solid, liquid and gaseous radioactive wastes and by-products. A description of the existing environment and information base is provided in Chapter 5 so that the impact of these main environmental issues can be assessed in Chapter 6.

In the plant, rare earths would be recovered from monazite (and xenotime if available) leaving water soluble and mobile radioactive materials naturally contained in the minerals. Radiation from the processing of the feedstock minerals and the disposal of solid, liquid and gaseous waste products are the environmental issues that are addressed in detail in Sections 6.7 to 6.9, with particular consideration being given to the ways in which plant personnel and the public would be protected from this radiation detailed in Section 6.10. Background information on radiation and radiation protection standards is detailed further in this chapter.

3.2 BACKGROUND INFORMATION ON RADIATION

All matter is made up of atoms, with different types of atoms having different chemical and physical properties. An atom consists of a positively charged central core, the nucleus, which contains nearly all of the mass of the atom and is surrounded by one or more negatively charged electrons. The nucleus contains positively charged particles called protons and particles with no electrical charge (neutral) called neutrons. Protons and neutrons have almost the same mass and are approximately eighteen hundred times more massive than electrons. In their normal state, atoms are electrically neutral, so the number of protons in the nucleus is balanced by the number of electrons in the surrounding cloud. Removal of electrons from an atom leaves it positively charged and the resulting particle is known as an ion. The chemical properties of different atoms are determined by the number of protons in the nucleus.

Atoms of the same chemical element always have the same number of protons in their nucleus, but when they have different numbers of neutrons they are called isotopes. There are ninety-two naturally occurring elements and several hundred naturally occurring isotopes.

The nucleus is held together by a very strong force of attraction between protons and neutrons in close contact. This strong force, or nuclear force, is sufficiently powerful at close range to overcome the electrical repulsion between the positively charged protons. For this reason, the nucleus is generally a strong, stable structure, and most of the naturally occurring isotopes are stable. However, this stability depends rather sensitively on the numbers of protons and neutrons. If an atom has too many or too few neutrons, the nucleus may be unstable, and may spontaneously change its state to reach a more stable condition.

The process of spontaneous disintegration of an unstable nucleus is called radioactivity. The nucleus is unstable because it has excess energy and some of this excess energy is emitted in a decay process which involves the release of energetic radiation. This radiation has a number of different forms, including alpha and beta radiation, gamma and X-rays, and neutrons. The unit of radioactivity is the becquerel, which corresponds to one radioactive atom decaying every second. Atoms which are characterized by unstable nuclei are termed radionuclides.

The time at which a particular radionuclide may emit radiation is completely random. However, for each isotope, there is a characteristic average rate at which a sample of the material decays. Because there are an enormous number of atoms in even a small sample of a radioisotope, it is possible to define statistically what is called the half-life of the isotope, that is, the time taken for half of the total number of atoms in a sample to decay. Half-lives of isotopes vary from millionths of a second for extremely unstable isotopes to 14 billion years.

The decay products of a radionuclide, termed 'daughters', may in many instances also be unstable and subject to radioactive decay. The decay process continues until a stable isotope is produced. Therefore, for any radionuclide there may exist a decay series or 'chain' of subsequent unstable daughters. Monazite and xenotime contain two such decay chains, originating from the radionuclides thorium-232 and uranium-238. These decay chains are shown in Figure 3.1.

The type of radiation emitted during the radioactive decay of a radionuclide is governed by the relationship between the radionuclide and the subsequent daughter product. If the nucleus is alpha radioactive, it spontaneously emits an

are exposed to various man-made sources of radiation including X-ray machines for medical purposes, emissions from luminous dials, nuclear explosives fall-out and the releases associated with nuclear power production. For example, the dose equivalent from a typical diagnostic X-ray is 0.2 mSv.

For people living in industrialized countries, the annual average dose has been evaluated to be about 2.4 mSv (Slatyer 1984). The contribution from the various sources of background radiation is shown in Table 3.2.

Table 3.2 Sources of radiation

Sources of radiation	Components of annual average dose 2.4 mSv received by people in industrialized countries
Radon gas in homes	40%
Medical (mainly from X-rays)	17%
Internal from naturally radioactive elements in the body	15%
Rocks and soil	15%
Cosmic rays from outer space	12%
Others (including occupational)	1%

Source: Slatyer (1984)

Exposure to alpha, beta and gamma radiation can have detrimental effects on humans and other living organisms. External exposure of the tissues of a person's body results from a source outside the body emitting gamma rays. Internal exposure results from radioactive atoms entering the body (breathing air, eating food or drinking water) through alpha, beta or gamma radiation.

To ensure that workers in the plant and the general public do not receive radiation doses that exceed recommended limits, the following potential sources of internal exposure to radiation have been addressed:

- airborne particulate matter containing respirable particles of monazite and/or thorium residue in which the alpha-emitting parent radionuclides thorium-232 and uranium-238, and their daughters, may increase lung dose when inhaled;
- alpha-emitting gases thoron (radon-220) and radon (radon-222) emanating from materials containing the parents thorium-232 and uranium-238;
- daughters of thoron and radon that may lodge in the respiratory system as radioactive particulate matter;
- alpha and beta-emitting radionuclides dissolved or suspended in process and groundwater which may be employed for personal use by workers or members of the public.

External sources include exposure to gamma radiation from members of the thorium-232 and uranium-238 chains contained in materials outside the human body. Monazite and thorium residue are sources of gamma radiation. Thorium and uranium hydroxides are also sources of alpha, beta and gamma radiation, although the alpha and beta rays are absorbed by the product itself and the packaging drum or barrel.

3.3 RADIATION PROTECTION STANDARDS

All radiation doses are measured as energy deposited per unit mass of tissue irradiated, or absorbed dose being the Gray or 1 joule/kg. Some types of radiation cause more harm than others for the same energy deposited so that dose equivalent is used which is the product of absorbed dose, the type of radiation received and other modifying factors. The unit of dose equivalent is the sievert. When irradiation is not uniform over the whole body it is possible to calculate an effective dose equivalent for various organs or tissues.

The draft guideline on Assessment of doses and control of exposure to meet the radiation protection standards, 1986 states that:

People have always been exposed to ionising radiation from terrestrial sources, cosmic radiation and radionuclides within the body. This natural background radiation varies from place to place but the average, for the world's population, of the effective dose equivalent received by individuals in a year is estimated to be about 2 mSv about half of which is due to inhalation of radon and radon daughters. The human race has evolved in this natural radiation environment, and the effects on health of such doses are not discernible.

However, harmful effects induced by ionizing radiation such as lung cancer in uranium miners, attributed to the inhalation of radon gas, have been observed.

The philosophy of radiation protection standards was developed by the International Commission on Radiological Protection (ICRP) and adopted by the National Health and Medical Research Council (NHMRC) as a set of radiation dose limitations. The Commonwealth Government, through the NHMRC, produces Codes of Practice and Guidelines for each State Government to utilize in their legislation. The Codes, Guidelines and Legislation are based on the following principles:

- . no practice shall be adopted unless its introduction is necessary and produces a positive net benefit;
- . all exposures shall be kept as low as reasonably achievable (the ALARA principle), economic and social factors being taken into account;
- . the dose equivalent to individuals shall not exceed the limits recommended for the appropriate circumstances.

The regulations distinguish between dose limits people who are exposed to radiation in the course of their work and dose limits for members of the general public. For occupationally exposed workers, such as medical radiographers or uranium miners, dose limits are set so that, when applied in conjunction with the ALARA principle, the average risks associated with their exposure are no greater than the risks incurred by workers in other occupations which have a high standard of safety. For members of the general public, dose limits are

determined by making radiation risks comparable with other risks in daily life, as distinct from occupational risks. The recommended annual dose equivalent limit for radiation workers is 50 mSv and for individual members of the public it is 5 mSv per year excluding the contributions from natural background radiation and medical uses of radiation provided that the average annual dose equivalent over a lifetime does not exceed 1 mSv a year.

Table 3.3 shows the relevant radiation protection standards for radiation workers and members of the public. Experience over recent years has shown that it is rare for the dose equivalent limits recommended by the NHMRC to be approached by radiation workers.

Table 3.3 Radiation protection standards

Category	Quantity	Maximum annual dose (mSv)	
		NHMRC recommended standards	New South Wales legislation
Radiation worker	Effective dose equivalent	50	50 *
	Dose equivalent to any single organ or tissue, excluding the lens of the eye	200-500 (depends on organ or tissue)	50-750 *
	Dose equivalent to the lens of the eye	150	150 *
Member of the public	Dose equivalent limit	5	5
	Lifetime average dose limit	1	-
	Dose equivalent to a single organ or tissue excluding the lens of the eye	20-50 (depends on organ or tissue)	5-75
	Dose equivalent to the lens of the eye	15	15

* Annual dose limits are generally one-third for radiation workers under the age of 18 years.

Source: Commonwealth of Australia (1981)
New South Wales Radioactive Substances Regulations.

In developing radiation protection standards, the ICRP assumed that there is no threshold dose for the induction of cancer and that the effect of radiation is directly proportional to the dose and is independent of dose rate. This assumption is conservative in the sense that it may over-estimate the risk at low doses but it is prudent to adopt this assumption in the setting of radiation protection standards. To produce guidelines for allowable concentrations of different radioactive materials in air, water or food, it is necessary to:

- . set the dose limit for the whole body exposure as a primary standard;
- . develop theoretical models which describe the distribution and retention of radioactive materials within the body and the dose equivalent delivered by a given intake of material;

- . use these models to relate concentrations of radioactive materials in the environment to the rate of intake of contaminated air, food and water, so that radiation doses may be calculated.

The above process has allowed the ICRP to determine exposure standards for various radionuclides. However, in many instances it may not be practical to set safety standards in relation to exposure; a set of derived limits of concentrations of radionuclides has therefore been included in the Commonwealth Government Code of practice on radiation protection in the mining and milling of radioactive ores (1980) (under revision) and the New South Wales Radioactive Substances Act, 1957 and Regulations, (1959). Derived limits are established as an aid in conducting a radiation protection programme as the basic radiation protection standards are the annual limits set by the ICRP. Derived limits are calculated from these annual limits using a model which normally assumes 'worst case' situations, such that adherence to the derived limit will provide virtual certainty of compliance with the annual dose equivalent limits. Derived limits are not used as mandatory limits for instantaneous exposure as it is recognized that short-term exposure levels may exceed derived limits and that personal dose equivalents can be minimized by controlling the time of exposure. Hence, failure to adhere to the derived limit would not necessarily imply a failure to achieve compliance with the basic radiation protection standards but would require a more careful study of the circumstances. For radiation workers, the derived limits are based on exposure to radiation over a 40 hour working week. For members of the public, the derived limits are based on exposure to radiation over a 168 hour week. The New South Wales Legislation also sets maximum permissible concentrations for disposal of radionuclides into air and water applicable to radiation workers and members of the public.

These radiation protection standards are usually met within operating plants by having controlled areas (access controlled to limit the radiation exposure of employees), supervised areas (access controlled to limit the radiation exposure of members of the public), designated employees (employees who work under conditions such that annual effective dose equivalents might exceed specified limits - other employees are non-designated employees), proper ventilation, dust control, air cleaning, barriers, shielding and good housekeeping. The object is to prevent radioactive material from entering the work environment and controlling exposure. Hence monitoring of exposure to radioactivity and intake of radionuclides by employees is also usually undertaken. Responsibilities for ensuring adequate radiation protection lie with employers, statutory authorities and radiation workers.

The transport of radioactive material is covered by regulations issued by the International Atomic Energy Agency and adopted in the Commonwealth Code of practice for the safe transport of radioactive substances (1982) (under revision). These regulations establish standards of safety that provide an acceptable level of control of the radiation hazards associated with the transport of radioactive material. The regulations for transport of radioactive material would apply to the transport of thorium and uranium hydroxides residue by road from the proposed interim waste repository to the final disposal site.

The Commonwealth Code of practice on the management of radioactive wastes from the mining and milling of radioactive ores 1982 specifies that radioactive wastes shall be managed so that exposure to radiation of employees and members of the public would be as low as reasonably achievable (ALARA principle) and within prescribed limits. The provisions of this Code would apply to the interim

waste repository and the final disposal site. In addition, the NHMRC Code of practice for the disposal of radioactive wastes by the user (1985) would apply for disposal of the solid wastes and residues.

All three Commonwealth Codes outlined above are enacted under the provisions of the Environment Protection (Nuclear Codes) Act, 1978 to ensure that the people of Australia and the environment are protected from possible harmful effects associated with nuclear activities. All three Codes were developed in consultation with the States and the Northern Territory and are regulated by the States. The regulating or 'competent authority' in New South Wales is the Health Department.

The Australian Safeguards Office would also need to issue permits for possession of thorium hydroxide (and transport by contractors) as required under the Nuclear Non-Proliferation (Safeguards) Act 1987 and the New South Wales Health Department would need to issue a licence for possession and use of radioactive substances as required under the Radioactive Substances Act, 1957.

CHAPTER 4

JUSTIFICATION OF THE PROPOSAL

4.1 MARKET DEMAND AND GOVERNMENT SUPPORT

There are sufficient world resources of rare earths in producing deposits to sustain present production levels at least through to the end of the century, and probably well beyond (United States Department of the Interior 1985). The forecast of world rare earth demand is for a continued growth of 2.6% per annum to the year 2000 based on demand for high technology applications (United States Department of the Interior 1985). However, as one rare earth or group of rare earths cannot be processed without co-producing other rare earths, a range of products is always produced. This is reflected in the price of rare earths, which also depends on purity and ranges from A\$9/kg for the cheapest rare earth (neodymium oxide), to A\$13/kg for the most common rare earth (cerium oxide) to A\$1,600/kg for europium oxide. Some individual rare earth metals are worth over A\$20,000/kg. The products that would be produced at the proposed rare earth processing plant have an added value far in excess of the monazite feedstock presently available for A\$600-\$800/t.

There is a growing recognition in Australia of the potential of rare earths and their numerous and diverse applications, particularly in advanced technology industries. The Commonwealth Government has identified rare earths as a target area requiring special priority under its generic technologies programme. The Commonwealth Scientific and Industrial Research Organisation is conducting research on applications for rare earths, particularly in rare earth magnets and superconductors.

The New South Wales Department of Mineral Resources has stated in a letter to Deckhand (Appendix D) that the processing of monazite to recover rare earths is a priority project for the Department and an opportunity for the State. The Commonwealth Minister for Resources and Energy has stated:

Our goal should now be to pursue a fully integrated rare earths industry in Australia. To the extent that minerals processing is economically feasible and consistent with sound industrial development it provides optimum economic benefits to the industry and the Australian community from our resources, including high value added for exports, increased employment and important downstream processing. In the case of rare earths there is also a strong link with high-technology manufacturing, which is expected to experience strong growth internationally in the medium term (Evans 1987).

The Commonwealth and State Governments both recognize the potential of downstream processing of monazite and have accordingly designated rare earth processing as a top priority area. Establishment of a rare earth processing plant in New South Wales would conform with Commonwealth and State Government policies of increased value added processing of minerals to further value added products and in downstream products through the promotion of advanced technology industries.

4.2 ADVANCED TECHNOLOGY INDUSTRIES

Advanced technology industries are those industries which develop new technologies, products and processes to gain an advantage in international markets. Industries which use rare earths in innovative products and processes can be classified as advanced technology industries. Individual rare earths are usually used in highly technical and advanced applications where cost is a secondary consideration to the technical advantages of the material. A recent example is the use of the rare earths samarium and neodymium in high strength permanent magnets, and yttrium in superconducting materials that are in turn used in a variety of applications and new markets. Other advanced applications include rare earths as hosts and activators in phosphors, magnetic and electronic materials, optical devices and ceramics.

Existing uses of rare earths, including those in advanced technology industries, are listed in Table 1.2. These uses and their applications have been recognized in Australia as an opportunity for advanced technology industries to develop, based on the production of rare earths by processing monazite. New products and markets could result from advanced technology industries with the proposed rare earth processing plant providing the impetus. Existing and potential applications of rare earths in advanced technology and other industries in Australia include:

- in magnets of substantially increased magnetic strength used in a wide range of devices including electric motors, bearings, communication equipment, linear accelerators, metal fragment retrieving instruments and medical applications including safe implants as dental prostheses and orthodontics;
- as ceramic and refractory materials for ceramic engine parts, electronic components, windows in high temperature furnaces, and in partially stabilized zirconia ceramics;
- in alloys and metals for improved galvanizing of steel, high voltage transmission lines and coatings for jet engine turbines; in superalloys for high temperature and pressure environments; and in high strength low alloy steels;
- in special electronic components such as bubble memory chips for calculators and computers, and high quality colour screens for television and video equipment;
- in medical equipment with special screens for enhancing the efficiency of diagnostic X-ray procedures and contrast agents for magnetic resonance imagery of the heart;
- as catalysts for use in catalytic cracking, automobile emission control systems, self cleaning ovens and ammonia synthesis plants;
- in hydrogen storage mediums providing a means of energy storage that is an alternative energy source for refrigeration and combustion purposes;
- in agriculture as a means of increasing crop yields and crop quality;
- other uses including magnetostriction effect devices to replace mechanical systems, high quality fluorescent lighting, microwaves, lasers, new ceramic materials, superconductors and corrosion resistant films.

4.3 ECONOMIC AND OTHER BENEFITS

The proposed rare earth processing plant would have economic and social benefits for Australia and for New South Wales and the Lismore region. If Australia continues to produce and export unprocessed monazite at current rates, returns would be only a fraction of their potential value. The 2000 t per annum of unprocessed monazite is presently worth up to A\$800/t or A\$1.6 million in export earnings. The Bureau of Resource Economics has stated that there is significant potential to substantially expand the value of Australia's non-energy mineral exports, including monazite, by increasing the degree of downstream processing before export. They have calculated the increase in gross value per tonne of processed monazite at 2.4 for light rare earths, 4.8 for light rare earth chlorides, 10 for heavy rare earth oxides and 150 for heavy rare earth metals (Bureau of Resource Economics 1987).

The proposed production of rare earths would include light rare earths, light rare earth chlorides and heavy rare earth oxides which would yield approximately a ten times increase in gross value added product depending on customer demands. As 97% of the rare earth product would be initially exported until local downstream and associated industries developed, the export earnings from the plant would be approximately \$16 million per annum. In addition there is a potential import substitution economic effect as Australia imports some rare earths. There is also the potential for further processing of rare earths into mischmetal and other rare earth metals and alloys that would increase with the commissioning of the rare earth processing plant and the even higher added-value product.

The production of rare earths may also encourage the development of associated downstream industries and related advanced technology industries with consequent economic and social benefit to Australia's economy. These industries could develop significant export markets in their own right.

Hence, the potential contribution of the rare earth processing plant is more than the initial and important increase in export earnings as it would also raise the awareness of the potential of the rare earth related industries. If the potential of rare earths became absorbed in the national consciousness, funding agencies would be more likely to view favourably related opportunities leading to enhanced national development. Further benefits would then be of strategic national importance through self sufficiency in selected strategic materials and development of advanced technology industries. For example, the development of a high strength permanent magnet industry using rare earths and their numerous electrical applications would have strong potential in Australia.

The proposed rare earth processing plant would also have direct regional economic benefits. The plant would initially provide employment for up to twenty people for plant operations with up to an additional 80 jobs created from downstream industries and plant servicing requirements. Twenty construction and professional workers would also be required for refurbishment of the existing buildings and installation of the rare earth processing plant. As Lismore has a relatively high unemployment rate it is expected that most of these employees and construction workers would come from the Lismore region. The resultant increased spending power would enhance the trading activities of Lismore retailers and businesses. The wages and salaries bill of the proposed plant is expected to be up to \$0.5 million per annum, most of which would be spent in Lismore.

Capital expenditure for purchasing the land, buildings and facilities, constructing the waste repository, internal access road, chemicals storage bund and other minor works, and installing the rare earth processing plant and safeguards would be approximately \$7 million. Annual operating costs are expected to be in the vicinity of \$11 million, \$5 million of which would be expended on feedstock, process chemicals, water and electricity. Up to \$2 million would be expended on wages, salaries and related costs, and \$4 million would be expended on maintenance and other goods and services. Extensive research and development costs are also anticipated by the proponent, particularly in the early stages. A proportion of these expenditures would benefit the Lismore region through supply of materials, goods and services, although suppliers of process chemicals and other materials in Brisbane and Sydney would also benefit. In addition, the proposed plant would pay an estimated \$3 million per annum in taxation payments, including company tax, mining royalties, payroll tax and municipal rates.

The proposed plant would also offer a number of more intangible economic and social benefits by:

- providing more information on rare earths in Australia;
- providing opportunities for developing education programmes and research and development at Lismore's tertiary institutions plus the potential employment of graduates;
- advancing Commonwealth and State Government economic development objectives;
- providing an advanced technology and related rare earth industrial base upon which further downstream processing and manufacturing could be established;
- creating opportunities for marketing new products and developing new markets;
- giving New South Wales a new base for industrial activity that could lead to further related developments;
- broadening the economic base of Australia and Lismore;
- reducing Australia's reliance on foreign sources of supply of rare earths;

4.4 ALTERNATIVE SITES AND REASONS FOR SITE SELECTION

Deckhand considered four alternative sites for the location of the proposed rare earth processing plant. One site is in New South Wales and the other three are in other States. These alternative sites cannot be disclosed because potential important commercial advantages could be gained by competitors; it would also be possible to relocate the proposed plant if the development did not proceed at Tuncester.

The evaluation of these alternatives took into account a wide range of qualitative and quantitative factors, with the main considerations being shown in Table 4.1. The location criteria were weighted as minor, moderate and major disadvantages or advantages relative to the alternative sites.

Table 4.1 Site selection factors

Criteria	Alternative Sites			
	Site 1	Site 2	Site 3	Tuncester
	(In States outside New South Wales)			New South Wales
Access to feedstock sources	●	*	*	*
Access to process chemical supplies	•	*	*	*
Access to port and airport facilities	•	*	*	*
Cost of electricity and water	*	*	*	*
Appropriate zoning	*	*	●	*
Existing municipal infrastructure	*	*	•	*
Existing site infrastructure	*	*	*	*
Availability of skilled labour	*	*	*	*
Buffered from residential development	*	*	•	*
Proximity to Currumbin Minerals corporate office	•	*	*	•
Development approvals required	*	*	*	*
Overall assessment	*	*	*	*

Advantage

Disadvantage

* major

● major

* moderate

• moderate

* minor

• minor

All four sites were rated as suitable locations for the proposed rare earth processing plant. One site was considered less suitable because of overall poor access to facilities and developed infrastructure relative to the other sites. The decisive factor which favoured the Tuncester site over the alternatives was the fully developed infrastructure and suitable buildings and facilities on site. In assessing the Tuncester location further, it was apparent that there were a number of economic and other advantages:

- . The buildings and utilities were established with only minor works required, which meant both cost savings and time advantages in establishing the proposed plant, providing the necessary government approvals could be met in reasonable time.
- . The buildings were of quality construction and their configuration was suitable for the proposed rare earth processing plant.
- . Major external changes were not required to the buildings and no major landscape modifications would be involved in establishing the proposed plant.
- . Municipal infrastructure (roads, sewerage, water supply, garbage collection) was already in place to accommodate the proposed plant.
- . The cost of electricity in New South Wales was equal to or lower than other States.
- . Lismore has a College of Advanced Education that has recently introduced science programmes and it is envisaged that in addition to possible technical interaction with the College some graduates might be able to find employment in the proposed plant or in associated industries.
- . Lismore has an appropriately qualified workforce for the proposed plant to draw on (Department of Social Security, Lismore office pers. comm. 1987).
- . Tuncester is appropriately located to draw on feedstock from Queensland and New South Wales for use in the proposed plant.
- . Tuncester is a rural locality and the proposed plant would be unlikely to affect nearby land uses.
- . There is additional floorspace and land available on site to accommodate development of associated industries;
- . There is provision on site to provide a railway siding if required for future transport of feedstock, process chemicals and rare earth products.

For the above reasons, the Tuncester site was selected as the preferred and most appropriate location for the proposed rare earth processing plant.

4.5 CONSEQUENCES OF NOT PROCEEDING WITH THE PROPOSAL

If the Development Application for the rare earth processing plant to be located at Tuncester, New South Wales, is not approved, or if development consent has excessively stringent or uneconomic conditions, then Deckhand

would propose locating the plant outside New South Wales. In addition, if the economic and timing advantages of utilizing the Tuncester site are lost through unreasonable delays in gaining all necessary government approvals, then the project might also be relocated outside New South Wales.

The consequences of not proceeding with the proposal are that implementation, and thus the economic benefits of the project, would be delayed because of relocation of the plant. Mineral sands would still be mined but exported without further processing. Construction of the plant would be of benefit not only to the State in which it was sited but also to Australia, and its relocation would result in lost opportunities for New South Wales. In addition, unnecessary capital would be expended on developing municipal and site infrastructure, acquiring land and constructing new buildings elsewhere while suitable buildings and infrastructure remain unused at Tuncester. Costs for transporting the monazite and other materials could also be higher if the plant were relocated elsewhere. The immediate benefits of locating the rare earth processing plant at Tuncester and the resultant foreign exchange earnings that would accrue to the national economy would also be enhanced in the short term. As production of rare earths from the proposed plant is programmed for late 1987 or early 1988 a 1 year delay caused by relocation, for example, would be equivalent to approximately A\$16 million in foreign exchange earnings, plus the value of rare earths imports opportunity cost, less the value of monazite exported. Australia would also have to continue to rely on foreign sources of rare earths during this period. Early approval of the rare earth processing plant would be in the national and State interest and would be of strategic importance to the national economy as it would promote Australian development of our resources.

There are also additional consequences of not proceeding with the proposal for the Lismore region. The modern plant located on site would remain underutilised for the foreseeable future. The infrastructure built for the site by the former site user, utility organisations and Lismore City Council would also continue to be underutilised. Liquid, solid and atmospheric emissions from the proposed plant would be avoided. Hence South Lismore sewage treatment works would not receive wastewater discharges from the plant; some solid wastes would not be disposed of at Lismore rubbish tip; the interim waste repository would not be constructed; and boiler, radon and thoron gases would not be discharged from the stack.

CHAPTER 5

DESCRIPTION OF EXISTING ENVIRONMENT

5.1 INTRODUCTION

Chapter 5 describes in detail the existing site development and environment including relevant characteristics of the surrounding area. The existing site development is fully described in Section 5.2 as very few modifications to buildings, facilities and infrastructure on site would be required for the proposed rare earth processing plant. Existing and proposed land uses and planning provisions for the site and surrounding area are outlined in Sections 5.3 and 5.4 respectively. Characteristics of the existing environment that the proposal could affect are provided as baseline information for assessing environmental interactions. These characteristics include sections on geology and soils (Section 5.5), meteorology (Section 5.6), hydrology (including groundwater and surface water - Section 5.7) and background radiation levels (Section 5.9). Transport infrastructure in the area and access to the site are also described in Section 5.8.

5.2 SITE DEVELOPMENT

A brief description of the location, site and timing of the proposed rare earth processing plant is given in Section 1.4. The 13.47 ha site has a northern boundary of 222.6 m to the Casino—Murwillumbah railway and Kyogle Road (30.2 m wide, and at an elevation of 22 m) and a western frontage of 613.3 m to Rifle Range Road (20.1 m wide and 7 m paved road width). Access to the site is gained from Rifle Range Road at five points with the remainder of the site perimeter being fenced. An unformed road, 20.1 m wide abuts the southern boundary.

The site is composed of three consolidated parcels as described in the Statement and Certificate on page i. On the northern portion of the site, the disused brewery complex occupies approximately 5.6 ha of a large, gently sloping (elevation 31.1 - 33.3 m) platform with batter slopes. A 2.3 m high security fence surrounds the developed portions of the site. The undeveloped southern portion of the site rises steeply southwards from an elevation of 33 m to 82 m at the south-east corner of the site. Consequently, the site enjoys rural landscape views over the Leycester Creek valley towards the foothills of the Konorigan Range which are part of the Great Dividing Range.

Lismore City Council's records show that the land is not prone to flooding or subject to slip or subsidence (Section 149 Certificate under the Environmental Planning and Assessment Act, 1979). However, access to the site from Kyogle Road can be impeded by flooding. Council advises there is no adopted policy that restricts development because of the likelihood of hazards such as a landslide, bushfire, flooding, tidal inundation and subsidence (Section 149 Certificate). There is no evidence of significant soil erosion on site. In addition, the site has no documented historic, anthropological, cultural or archaeological significance. (Department of Environment and Planning and National Parks and Wildlife Service, pers. comms. 1987).

The existing modern building complex, with floor space in excess of 10,000 m², is set among landscaped grounds with scattered mature native trees, exotic shrubs, garden areas and lawns around the buildings. These landscaped areas would be retained and maintained. The buildings are linked by drained concrete and bitumen access roads. Elevated and covered pipe bridges to carry services also link the powerhouse, small and large factory areas and storage silos.

The buildings, facilities (Figure 1.2) and utilities on site are described below:

5.2.1 Office and amenities building

This single level building, which covers 582 m², is built on a concrete slab and has brick external walls and metal deck roof and fascias. Internal configuration includes air-conditioned individual and general offices covering 240 m², a laboratory, conference room and first aid room, showers, washroom, locker facilities, cleaning room, dining facilities and plant room. A waste collection pit and pump room abut the office building. The office building is linked to the gatehouse by a footpath and is surrounded by extensive landscaped areas.

5.2.2 Large factory

A large factory (former bottling hall for the brewery) covering 3,645 m², has concrete floors, universal column and beam portal frame, external brick walls to sill height, and Colorbond metal to the eaves. The building is insulated, and lined internally, and has sprinklers, mercury vapour and natural lighting throughout with extensive reticulation of compressed air, steam and water services. An in-floor drainage system complete with grating is installed. A mezzanine floor accommodates the factory office, and toilet facilities are located inside the building. The bottling plant has been removed leaving a clean and clear span floor area. A large bitumen surface storage area is located to the east of the factory.

5.2.3 Warehouse

A warehouse covering 3,636 m² has similar construction and services to the factory, to which it is connected by an internal ramp at a lower level. A four hour rated fire wall separates the warehouse and factory. Access is via an extensive concrete forecourt delivery area and five large doors. A covered loading dock of 492 m² adjoins the warehouse at a higher level. An in-floor centre line drain covered with grating is installed. Office and toilet facilities are provided on a mezzanine floor. Additional storage area is located under the warehouse which is partially cantilevered northwards off the excavated platform. The northern and eastern boundary walls of the warehouse have been planted with trees and shrubs that hide the storage area underneath.

5.2.4 Small factory

The former brewhouse covering 810 m² is constructed of a 17 m high heavy portal frame, and is clad externally and lined internally with colourbond metal. The internal space has been subdivided but the majority of the floorspace has a three-storey clear span and is partially occupied by a large stainless steel steam jacket vessel of 122 m³ capacity and 6.9 m diameter. The vessel is supported on universal beams with a 6.5 m high surrounding mezzanine working level protected by handrails. The south-west corner of the factory has an enclosed two-level mezzanine structure occupied by machinery and storage areas. A one-storey enclosed storage area also occupies part of the southern floorspace area.

The ground-level floor is of concrete with an in-floor drainage system protected by metal grating. An eyewash station is located on the southern wall of the factory. Natural lighting and ventilation are provided via the 1.5 m high throat ridge vent on the rooftop with bird and insect screens on the windows.

5.2.5 Receiving hopper and storage silos

Adjoining the small factory is a one-storey receiving hopper for gravity tipping of material through grating into a below-ground storage bin. Materials are then transferred by screw conveyor with dust extractor attached to three large, circular, two-storey iron storage silos located south of the small factory. Five circular 19 m high vertical fermenters and storage shed are located north of the small factory. The fermenters would not be used in the rare earth processing plant and would be removed within 2 years.

5.2.6 Powerhouse

The powerhouse and main switchroom occupy a one-storey, clear span, portal framed building of 992 m² that has brick to sill height and a metal deck roof with ridge ventilation and natural lighting. Other features include in-floor drainage, 2 hour fire rated doors, toilet, lunch room and store area. Plant includes two oil-fired boilers (rated to 3,930 kg/h), extensive electrical switch gear, dryers, refrigerant and compressed air equipment. An electricity substation, high-voltage switch room and 52 m high stack supported by three guy wires adjoin the powerhouse. The stack encloses four 52.54 m high flues. Two fuel oil storage tanks each of 125 t capacity are located in a bund south-west of the powerhouse. A condenser platform is also located south of the powerhouse but the equipment has been removed.

5.2.7 Caretaker's cottage

The three-bedroomed caretaker's cottage, which covers an area of 124m², is of brick veneer construction with timber floors, tiled roof and attached water storage tank.

5.2.8 Gatehouse and car parking areas

An enclosed gatehouse controls access via boom gates and weighbridge at the main entrance off Rifle Range Road. A paved and night lit employee car park for seventy-eight cars is located north of the gatehouse with separate access off Rifle Range Road. The car park is surrounded by landscaped areas including a large advertising structure adjacent to the northern boundary. An additional landscaped visitor car park is located west of the office block.

5.2.9 Water supply

Raw water supply from the Lismore City Council system enters the site at the north-east corner with an unmetered branch for firefighting and a metered branch to the water treatment building which houses pumping equipment, fire sprinkler controls and a water treatment plant. The metered water supply has a capacity of 694 ML/a.

5.2.10 Water treatment plant

The water treatment plant automatically filters, chlorinates, dechlorinates, stores and reticulates water. The chlorinated (treated) water goes to the large factory and warehouse via the 0.9ML storage reservoir for general cleaning, fire

hosereels and a lawn watering system. Filters such as activated carbon would be used to dechlorinate water that goes to the small factory, powerhouse and office and amenities building for process use, drinking and ablutions.

5.2.11 Waste collection system

A trade waste collection system receives liquid process wastes from the floor drains in both factories and loading dock via a collection pit of 0.18 ML capacity located next to the office building from where it is pumped up to the waste treatment works. A separate system also delivers diatomaceous earth in suspension through pipes to bins at the waste treatment works. The floor drains to the warehouse discharge through trapped and water sealed sumps then directly to the sewer as do the powerhouse floor drains that also have an oil and water separator. Laboratory waste is diluted in a separate pit before it is pumped to the waste treatment plant. In the event of a malfunction of the collection pit pump, the wastes would overflow into the stormwater system.

5.2.12 Waste treatment plant

The trade waste treatment plant receives trade waste pumped from the waste collection pit via an averaging tank for neutralization, aeration, clarification and discharge into the sewerage system. An automatic dosing pump adds solution to the waste to correct its pH level to within a pre-determined range. The two low-speed aerators installed in a large tank can operate continuously and are capable of handling 639 ML/a of waste with inputs of 1,250 mg/L biological oxygen demand and 330 mg/L suspended solids. Aerated waste then flows to a clarifier where sludge is separated from effluent before the sludge is recirculated back into the aeration tanks. The effluent then flows from the clarifier into the site's sewerage system. The equipment has been designed so that effluent flows will be less than 300 ppm biological oxygen demand and 300 ppm suspended solids. The waste treatment plant has a large, flat, paved platform area and the plant is security fenced.

5.2.13 Sewerage system

The main line of the site's sewerage system of 788 ML/a capacity takes effluent from the trade waste treatment plant to Lismore City Council's pump station located north-east of the site. Branch lines pick up the backwash from the water treatment area, and sewage from the cottage, office block, factory office washroom, warehouse washroom and gatehouse. The floor drain from the warehouse and water from the powerhouse floor is pumped via an oil separator into the sewer. A flow meter has been installed in the line so that Lismore City Council can charge for sewage treatment.

5.2.14 Stormwater system

The stormwater system which collects all roof and surface water is constructed of concrete kerb and gutters with pits and drains that discharge into headwall dissipators located at various points around the perimeter of the developed portion of the site. Lismore Council drains under Rifle Range Road collect most of the site's stormwater that is directed to discharge on open, flat public land opposite. The drainage system is designed to accommodate a 1 in 5 year storm or a 5 minute storm with an intensity of 165 mm/h. In addition, a contour drain follows the 42 m level to catch runoff from the undeveloped portion of the site to discharge into a 35 m long weir located south of the waste treatment plant. The weir overflow rate is designed for a 20 minute storm of 83 mm/h with a runoff coefficient of 0.80 or a 1 in 5 year storm.

5.2.15 Fire services

Fire services include an automatic sprinkler system, ring main hydrants and hoses supplied by unmetered water of 94 ML/a capacity from a fire storage tank within the buildings connected to the chlorinated domestic water service. The large factory and warehouse are equipped with a sprinkler system connected to the Lismore fire brigade and flow in the system automatically raises alarms in Lismore and the factory. An electric pump automatically operates when the system is activated, with an automatic diesel back-up pump in case of power failure. Additional water supply for the sprinklers comes from a service tank and the reservoir in case of extended emergency. The ring main is also boosted by an automatic electric pump. Seventeen outlet hydrants are distributed around the site and if a hydrant is opened an alarm rings after a 25 second delay until the flow in the line switches on the electric pump. Foam extinguishers located at strategic points in all buildings supplement the above systems.

5.2.16 Other infrastructure

Other infrastructure includes electricity supply, telephones, automatic external security lighting, telex and an internal public address system.

5.3 LAND USE

The 13.47 ha site was developed as a modern brewery with associated facilities and infrastructure. Most of the brewing equipment, some vertical fermenters, and air conditioning plant have been dismantled and removed from the site leaving the building structures, infrastructure and essential facilities. The only use to which the developed portion of the site is presently put is for the maintenance of essential plant and equipment such as the power, water treatment, wastewater and fire plants by a caretaker and staff, and security surveillance to ensure the integrity of the site and plant for future use. The office and amenities building is also used in support of this maintenance. There is no resident population on site. The undeveloped southern portion of the site of approximately 7.9 hectares is vegetated with a few trees and introduced pasture that is grazed by a small herd of cattle. There is little habitat on site that is capable of supporting native wildlife. Hence the existing land use of the site is basically vacant buildings and some minor animal husbandry.

The site is classified (in its undeveloped state) by the Soil Conservation Service of New South Wales as 'Class IV land not capable of being regularly cultivated but suitable for grazing with occasional cultivation'. The surrounding flat lands are classified as 'land capable of being regularly cultivated'. The site and surrounding lands are also classified by the Department of Agriculture as 'Class 3 land suitable for grazing land or land well suited to pasture improvement'. The predominant land use in the surrounding area is grazing by cattle on pastures, with some cropping (mainly soya beans) on prime agricultural land along Leycester Creek floodplain (refer to Figure 5.1).

Viewed from the site, the dominant landscape features are the Leycester Creek valley floor surrounded by the grassed footslopes and wooded spur tops of the Konorigan Range. The valley floor and footslopes are vegetated with introduced pastures, and low-lying portions of the valley are also swampy. Three occupied dwellings are located 100 m north of the site at the north-west intersection of Kyogle and Rifle Range Roads. Seven occupied dwellings are located within a 1 km radius of the centre of the site and, based on an average occupancy rate of four persons per dwelling, around thirty people live within 1 km of the centre of

the site. Another eighteen occupied dwellings are located in a 1 - 2 km radius of the centre of the site and, based on the above occupancy rate, around 100 people live within 2 km of the centre of the site.

Three lots occupy the west side of Rifle Range Road opposite the site. The northernmost lot will be occupied by a car wreckers yard and dwelling under construction on a 2.98 ha lot. South of this lot, Lismore City Council owns 3.72 ha of vacant land. The southernmost lot of 33.37 ha opposite the site is owned by the Commonwealth Government and is used as a rifle range by two clubs for small bore rifle and pistol target shooting four times a week. Seven buildings used by club members occupy the rifle range site. Large calibre shooting is not permitted because residences lie within the safety zone. Private pasture lands east and south of the site are used for cattle grazing. The South Lismore sewage treatment works is located 3 km south-east of the site and Lismore lies 5 km east of the site.

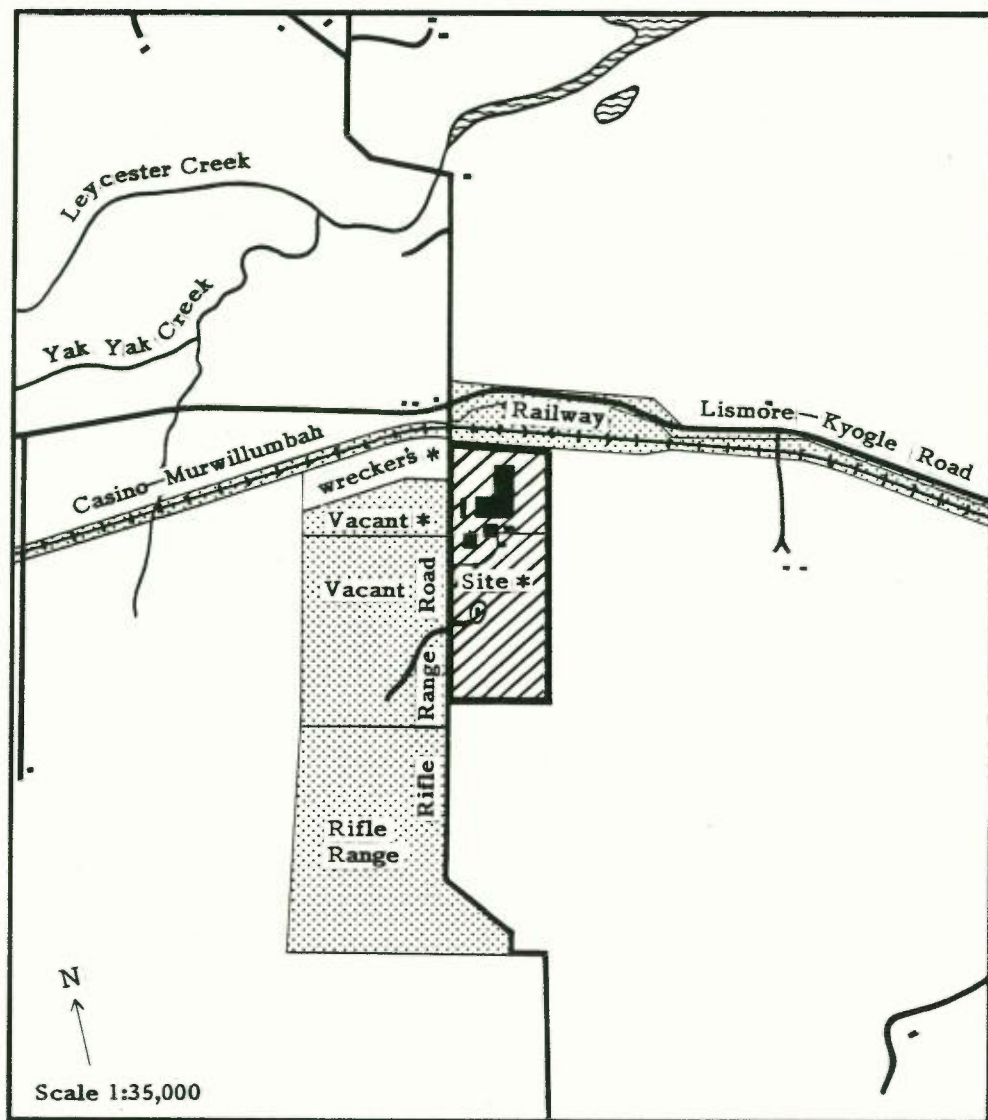
Figure 5.1 shows the generalized land use and ownership of the area within 1 km of the site.

5.4 PLANNING PROVISIONS

The site is zoned Rural 1 (a2) under Lismore City Council's Interim Development Order No. 40 gazetted on 29 August 1980 (as amended). Under this zoning the proposed rare earth processing plant is a purpose for which development may be carried out only with the consent of Lismore City Council. Agriculture and forestry are permitted without Council's consent and the construction of dwellings are subject to conditional consent. Lands surrounding the site are zoned Rural 1 (b) on which agriculture and forestry are permitted without Council's consent. The development potential of these surrounding lands is constrained by an extensive list of prohibited land uses, and hence agricultural uses should generally prevail in the future. Owing to the constraints of the Rural 1(b) Zone it is unlikely that the population within 2 km of the site would rise significantly in the future although the Caniaba area 3 km south of the site has potential for population growth.

The Interim Development Order No. 40 as amended will be repealed by the draft Lismore Local Environmental Plan 1986 that was on exhibition until 29 May 1987. Under this draft plan, the site and adjoining lots of 2.98 ha and 3.72 ha west of the site are proposed to be zoned General Industrial. Under this zoning industry such as the proposed rare earth processing plant will be permitted only with the consent of the Council. Lands surrounding the site and General Industrial Zone are proposed to be zoned Rural 1(a) General Agricultural Zone with a wide variety of agricultural uses and some industries permitted. In addition, the draft North Coast Regional Environmental Plan 1987 is on exhibition until 31 July 1987. There are a number of provisions in this draft plan that may influence the development of the site including:

- current regional development policies for industry encourage a 'value added' approach - processing of local resource based products to increase their value before leaving the region;
- in most cases it will not be appropriate for industrial development to locate in isolated rural areas and location close to existing industry and services is desirable;
- industrial areas should be located where they can be adequately serviced by the transport system and are accessible from urban areas.



- Occupied dwelling
- Private grazing lands
- ▤ Public lands
- Existing road or track
- * Proposed general industrial zone
- ▦ Water

Figure 5.1 Land use and ownership

The proposed rare earth processing plant would be in accordance with existing and draft planning provisions for the site and region.

5.5 GEOLOGY AND SOILS

The bedrock geology of the Lismore area in which the site is located, is formed from basalt which varies from coarsely crystalline and massive with jointing and vesicular zones, to highly weathered with interbedded clay, sand and gravel (Chesnut and Swane 1980). The bedrock has been deeply incised by the Richmond River system, when lower sea levels prevailed, forming steep-sided valleys. These valleys are now filled with alluvial, estuarine and marine clay sediments and silty sands (Drury 1982) forming broad, flat valley floors. Bedrock beneath the valley sediments is highly weathered vesicular basalt with a high proportion of clay. Bores near Tuncester show that the valley soil consists of a clay loam underlain by clay and minor amounts of sand and gravel. The site is located on gentle to steep slopes above the level of the Leycester Creek valley floor on highly weathered basalt, near the margin of the valley sediments.

Prior to development of the site as a brewery, detailed investigations of soils and surficial geology were undertaken by Soil Surveys Pty Ltd in 1978. The soil and underlying geology was sampled by drilling 28 boreholes and 21 pit excavations. In general, the surface soil was found to be high in clay content (mostly clays or sandy clays) and was underlain by very highly to completely weathered basalt, also high in clay content. No mineral deposits were encountered in the samples to a depth of 9.1 m. The depth to the weathered basalt was generally less than 1 m. This supports a description of soils in the area by Nicholls and Tucker (1956) who reported that a shallow clay loam soil occurred on slopes less than 15° on highly weathered basalt bedrock. Soils on the Leycester Creek valley floor were reported to be deep clays which are poorly drained and dominated by shrink-swell clays with 70% or more clay content.

The site and surrounding area is located in a seismic zone in which there are no requirements for the earthquake-resistance of buildings (Standards Association of Australia 1979)

5.6 METEOROLOGY

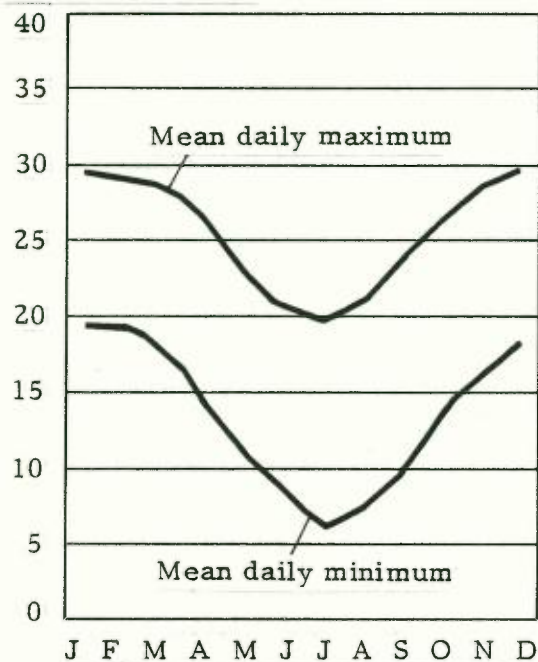
The far north coast region can be classified as humid sub-tropical. Meteorological data for Lismore are discussed as no data are available for the Tuncester locality. Topography on site (elevation 22 m to 82 m with gentle to steep slopes) and local conditions around Tuncester would cause variations from the Lismore data (elevation 10 m plus and flat to hilly) although the pattern would be consistent with Lismore. Some meteorological data for Lismore are shown in Figure 5.2.

Average annual rainfall is 1,354 mm at Lismore with about 65% occurring in the warmer months from November to April. Much of this summer rainfall is the result of intense falls accompanying tropical cyclones particularly in February and March. Severe local storms accompanied by strong winds, intense rain and possibly cyclones infrequently affect the region. There are, on average, 126 raindays each year.

Summer can be uncomfortable with temperatures of 30°C or more and high humidity. January is the hottest month with average maximum temperatures of

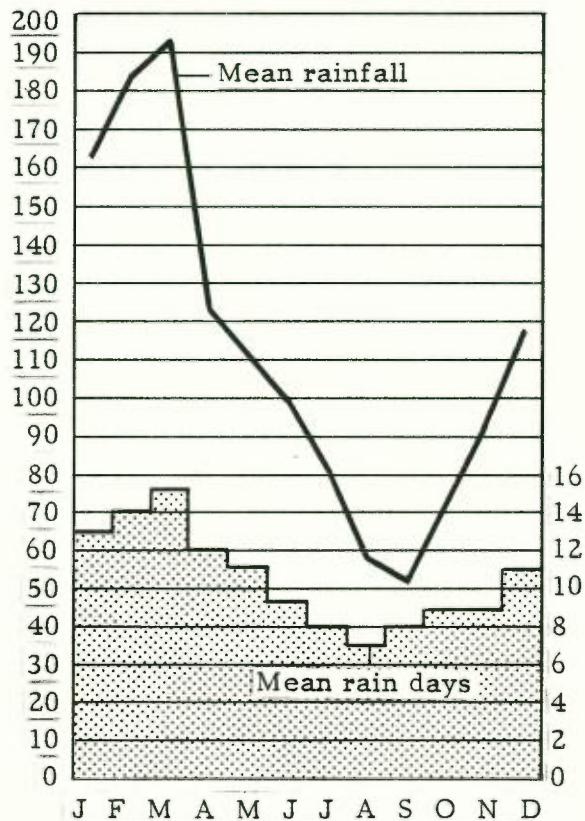
Figure 5.2 Lismore meteorological data

(°C) Temperature

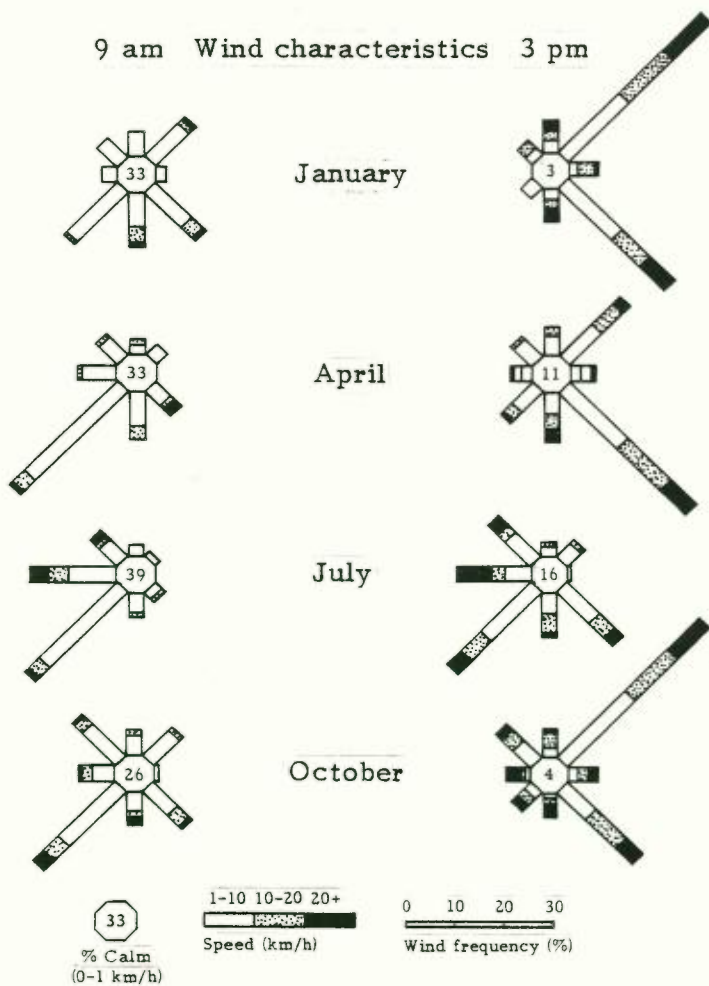


Rainfall (mm)

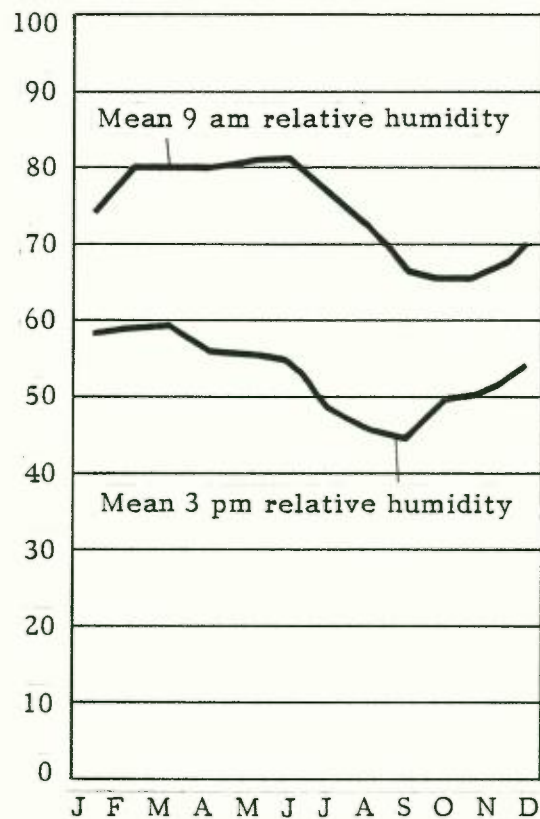
Raindays (number)



9 am Wind characteristics 3 pm



(%) Humidity



Source: Bureau of Meteorology

30°C. Winters are mild with average maximum temperatures around 21°C. The year round mean daily maximum and minimum temperatures are 25.5°C and 13.4°C respectively.

Main features of the wind regime at Lismore are that winds blow most frequently from the north-east and to a lesser extent the south-east in the period from September to March and mainly from the south-east and south-west from April to August. The frequency of winds and wind speeds are also greater in the afternoon than in the morning, although wind speeds are generally less than 10 km/h. Mornings are calm for an average of 33% at 9 a.m. and only 8% at 3 p.m. There are also more calm conditions in winter compared with summer. The site is likely to be windier than Lismore because it is situated on an exposed sloping spur.

5.7 HYDROLOGY

The average annual rainfall is 1,354 mm at Lismore, with 40% of this amount falling from January to March when there may be intense rainfall. Streamflow is highly variable, but persists for long periods after the cessation of runoff from rainfall. Back, Leycester and Terania Creeks act as sinks for groundwater discharge in the Tuncester area. In 1975, water levels in bores near Tuncester varied from 2.8 m below ground level in the bedrock to 10.6 m below ground level near Terania Creek. Both the bedrock and the valley sediment are of low permeability, except where lenses of coarse sand and gravel are encountered (Drury 1982).

A large platform was excavated on the site in 1978 to provide a gently sloping area on which the brewery was built. These excavations removed the soil and exposed the weathered basalt, thus altering the natural drainage patterns. Hydrological characteristics of the soil and weathered basalt would be very similar since both have low permeability owing to their high clay content. Therefore, during rainfall, runoff would take place both on the soil and the weathered basalt where excavated and unsealed. It should be noted, however, that the water table was not encountered in any of the boreholes or pits, including a 7.55 m borehole in the north-west corner of the site and a 9.1 m borehole in the centre north of the site.

The Department of Water Resources has details of one bore hole and one well that have been sunk on site. In 1974, a well was dug to a depth of 7.6 m near the middle of the northern boundary of the site for stock and domestic use. Two aquifers were encountered, both of 0.3 m thickness, at depths of 3.4 m and 7.3 m. In 1975, a bore was drilled to a depth of 34.1 m near the western face of the existing office building for general use. One aquifer of 1.5 m thickness was encountered at a depth of 13.7 m. Other bores and wells sunk in the surrounding area have generally encountered a pressure aquifer confined by a clay layer of variable thickness.

The on-site stormwater system collects and discharges the majority of roof and surface water into Lismore Council culverts under Rifle Range Road to flat publicly owned land approximately 1 km from Yak Yak and Leycester Creeks. Leycester Creek is a tributary of Wilsons River which flows southwards to enter the Richmond River at Coraki which then flows northwards to enter the sea at Ballina approximately 100 km downstream from the site.

The Richmond River system has a record of major flooding and as a consequence flooding of Leycester Creek can cause access to the site to be cut off one or two days a year.

CHAPTER 6

ENVIRONMENTAL IMPACTS AND SAFEGUARDS

6.1 INTRODUCTION

Chapter 6 describes the environmental interactions between characteristics of the proposed rare earth processing plant and characteristics of the existing environment. Any environmental impacts are assessed and appropriate ameliorative measures and safeguards are detailed for significant impacts.

Environmental impacts directly related with physical aspects of the proposal are described in sections dealing with plant refurbishment, land use, infrastructure and energy requirements and traffic and transport. Social and economic effects are also outlined. Most of the above effects discussed in Sections 6.2 to 6.4 involve those matters for consideration by consent authorities in determining a development application.

The major part of chapter 6 discusses in detail those particular environmental interactions and waste disposal methods associated with the proposed rare earth processing plant and the special requirements of the Department of Environment and Planning and Lismore City Council. Disposal of radioactive and non-radioactive wastewater discharges, solid wastes for the interim waste repository and atmospheric emissions are detailed along with appropriate safeguards. Worker and public health and safety issues associated with the proposal are discussed and safeguards outlined. A preliminary risk assessment covers areas of potential hazard including chemical processes, agricultural output, oceanographic and coastal environments, and the emergency responses to be developed in relation to these hazards.

6.2 PLANT REFURBISHMENT EFFECTS

The scope of works and timing of the plant refurbishment and commissioning are outlined in Section 2.11. Twenty construction and professional workers would be required over the 3 month refurbishment period to construct certain works and install the rare earth processing plant and safeguards.

The main effect during plant refurbishment would be the increase in heavy traffic to the site along the Lismore to Kyogle road. The number of heavy goods vehicles carrying plant and construction vehicles, such as concrete trucks, would increase but would be less than during the operational phase of the project. There would be a short term, increase in demand for construction materials and construction labour from the Lismore region. As most of the refurbishment works would involve modification and installation of plant in the internal areas of existing buildings the direct impact of construction would be minimal. There would be some short-term localized noise as a result of construction equipment and activity, but it is unlikely that surrounding residents would be disturbed. The construction of the internal access road, waste repository and chemicals storage bund would involve some short-term and localized dust and noise emissions. Yak Yak Creek might receive some silt loadings in storm waters from

the road formation and site earthworks for new facilities if there were heavy rain during construction. Lismore rubbish tip would be expected to receive additional solid wastes such as packaging and unsalvageable construction materials during plant refurbishment.

In general, the effects of plant refurbishment would be short term, irreversible and localized, with minor adverse effects of noise, dust and silt emissions and beneficial effects of increased demand for labour and materials as a result of construction activity. The adverse effects are normally associated with construction activity and would be minimized by the proponent as far as possible. For example, construction activity could be limited to specified hours if nearby residents were to be unduly affected by noise, and dust emissions could be minimized by wetting the ground during dry and windy days.

6.3 LAND USE EFFECTS

The main land use effect would be the proposed change in land use from vacant buildings and minor animal husbandry to a rare earth processing plant. However, as most of the proposed works and installation of plant and safeguards would take place within existing buildings, with only a few major external modifications to the site, the land use environmental impacts would be minor. Nevertheless, the proposed rare earth processing plant would be in accord with existing and draft planning provisions for the site and region.

The character, location, siting, bulk, scale, shape, size, height, density and external appearance of the existing development on site would basically remain unchanged. The site and shape of the land to which the development application relates, and the siting of any building or works thereon also basically remains unchanged.

The total area of the proposed major external modifications to the site would be approximately 0.4 ha or 3% of the site area. The developed portion of the site would then be about 6.0 ha or 45% of the total site area for use as a rare earth processing plant. Grazing of the undeveloped portion of the site under pasture would continue for site maintenance purposes. The loss of the small portion of grazing land on site is considered insignificant.

The few major external modifications to the site would include the construction of an interim waste repository, internal access road and chemicals storage bund. The main environmental impacts of these works would be their minor visual impact when viewed from outside the site. The chemicals storage bund would be constructed on the existing concrete platform that previously supported vertical fermenters. These fermenters were previously visible from the Lismore to Kyogle Road. The proposed chemicals storage bund would be built below the building line of the large factory and screened by the remaining vertical fermenters. The proposed bund would not be visible when viewed from outside the site until the remaining vertical fermenters were removed when it would then be visible only from Rifle Range Road. The proposed internal access road and interim waste repository would both be visible from Rifle Range Road and the Lismore to Kyogle Road. However, as the proposed access road basically follows the existing topography, with only minor earthworks required, and as the proposed waste repository has a similar elevation and construction to the existing adjacent waste treatment plant, the visual impact would be minor. The proposed internal access road and interim waste repository would also cause some disruption to soils during construction. These effects would be of a minor nature.

5.8 TRANSPORT AND ACCESS

The site is located 5 km west of Lismore at Tuncester on the Lismore to Kyogle Road about 10 minutes drive from Lismore depending on traffic conditions. The Pacific Highway is 38 km to the east and Casino is 26 km to the west. The site has frontages to Kyogle and Rifle Range Roads, both roads being two-way single lane sealed roads. The Lismore to Kyogle Road is classified and maintained by the Department of Main Roads as a main road. Rifle Range Road is a local access road and has a 7 m wide sealed carriageway to the visitor car park and is unsealed thereafter. Vehicular and pedestrian access to the site is from Kyogle Road, over a railway crossing to the main entrance approximately 60 m southwards along Rifle Range Road. The main entrance has a two-way 14 m wide sealed road leading to a gatehouse and weighbridge. Other vehicular access points to the site include a 6 m wide crossover to the employee car park, entry and exit crossovers to the visitor car park, an entry gate leading to an unsealed roughly formed accessway to the caretaker's house and sealed access to the waste treatment plant. Internal pedestrian access is provided via footpaths to the office building from the visitor car park, employee car park and gatehouse. Annual average daily traffic volumes near the site in 1982 were 1,030 vehicles a day along the Lismore to Kyogle Road 8 km west of the site, and 460 vehicles a day on the road to Nimbin and Rock Valley 500 m north of the site. These traffic volumes are well below road capacities.

The Casino—Murwillumbah railway traverses the Kyogle Road frontage of the site. Daily passenger trains travel from Sydney to Murwillumbah via Casino. Freight trains terminate at Casino from where freight is distributed by road. A bus stop is located approximately 2 km west of the site on Kyogle Road for the Casino to Lismore service.

Casino and Lismore both have airports. Casino is the main regional airport with three flights daily between Casino and Sydney. Lismore airport has two flights daily between Lismore and Brisbane and one flight daily between Lismore and Newcastle. Both Casino and Lismore airports are accessible by road from the site.

Table 5.1 Background radiation levels

Sample	Location	Radiation type		
		Alpha	Beta	Gamma
Air	On site	-	-	0.1 to 0.15 μ Sv/h(mean 0.11)
	Lismore	-	-	0.1 to 0.15 μ Sv/h(mean 0.11)
Soils	On site - sample A	0.15 Bq/g	0.34 Bq/g*(0.34)	
	On site - sample B	0.15 Bq/g	0.33 Bq/g*(0.30)	-
	Lismore - sample A	0.18 Bq/g	0.36 Bq/g*(0.34)	-
	Lismore - sample B	0.21 Bq/g	0.38 Bq/g*(0.37)	
Water	Yak Yak Creek	<0.07 Bq/L**	<0.1 Bq/L**	-
	Leycester Creek	<0.07 Bq/L**	<0.1 Bq/L**	-
	Wilsons River	<0.07 Bq/L**	<0.1 Bq/L**	-

* When corrected for potassium 40 levels (shown in brackets) are slightly lower.

** These are the limits of detection.

Source: Australian Nuclear Science and Technology Organisation and Queensland Institute of Technology (1987) for Kinhill Engineers

5.9 BACKGROUND RADIATION

Existing background radiation levels for the site and Lismore were measured and analysed in April and May 1987. The gamma survey of the site and Lismore was completed by Dr B. Thomas of Queensland Institute of Technology in April 1987. The alpha and beta analyses of composite soil samples from the site and Lismore region, and water samples from Yak Yak Creek, Leycester Creek and the Wilsons River downstream of Lismore, were undertaken by the Australian Nuclear Science and Technology Organisation in May 1987. The background radiation level results are shown in Table 5.1, and represent normal natural background radiation levels.

The existing and likely future land use and amenity of the neighbourhood is detailed in Sections 5.3 and 5.4. The locality presently has rural landscapes and land uses although this will change in the immediate vicinity of the site in future. Construction of the car wrecker's yard opposite the site's main entrance and an unspecified general industry on the adjacent site as foreshadowed in the draft Lismore Local Environmental Plan would mean a minor loss in rural amenity for the surrounding population. However, as it is unlikely that the existing small resident population within 2 km of the site would rise significantly in the future, relatively few people would be affected by the minor loss in amenity.

Other minor and localized land use effects include:

- . the caretaker's cottage would be occupied to ensure plant security, although the proposed 24 hour operation would also mean the site is continually monitored;
- . existing external security lighting on the developed portion of the site would operate at night with a resultant increase in localized lighting levels;
- . the existing general noise level in the vicinity of the site would be dominated by agricultural activities and road traffic. Future noise levels in the vicinity of the site would increase above existing noise levels due to a combination of new noise generating sources, such as construction traffic, workforce traffic, heavy vehicles carrying feedstock and chemicals and unknown industrial activity adjacent to the site. It would be unlikely that there were adverse noise levels beyond the site boundary although some provisions under the Noise Control Act, 1975 and Australian Standard 1055 would be exceeded for short periods of time due to heavy vehicle movements to and from the site. The proponent would apply to the State Pollution Control Commission, after Development Application approval, for a licence to operate the plant under requirements of the Noise Control Act, 1975;
- . any smells from the process would be confined to the solvent extraction area within the large factory;
- . surrounding land uses including grazing, cropping, the car wrecker's yard under construction and use of the rifle range would not be adversely affected by the proposal;
- . all existing landscaping would be retained and maintained;
- . the existing sign on the site frontage would be retained with the wording changed to 'Rare Earths Australia';
- . as a result of the proposed change in site use there would be no increased likelihood of flooding, tidal inundation, landslip, subsidence or bushfire. There would be some minor localized short term increase in soil erosion due to construction works.

The above minor land use effects would have localized environmental impacts and no ameliorative measures are considered necessary apart from the existing and proposed safeguards described in the EIS. In addition, there are no known representations made by a public authority in relation to the development application or to the development of the area apart from the general State government policy support.

6.4 INFRASTRUCTURE AND ENERGY REQUIREMENTS

The use of public utilities and infrastructure would be at levels no greater than, and generally less than those of the former site user. Electricity and fuel oil consumption and use of surrounding roads would be less than the former site user (Carlton and United Breweries, pers. comm. 1987). Use of Lismore Council's water supply, storm water drainage, sewerage and sewage treatment systems would be at levels comparable to those of the former site user. Use of other utilities such as telephones and telex would be at lower levels compared to the former site user until full development of the site by associated and downstream industries occurred. Use of other community infrastructure and services such as fire, ambulance and police services and medical facilities would be at a comparable level to the former site user. All utility services and infrastructure are available and adequate for the proposed development. Table 6.1 shows the proposed annual infrastructure and energy requirements for the proposed rare earth processing plant.

Table 6.1 Infrastructure and energy requirements

Utility/Energy Source	Annual Requirement
Electricity	2-3 x 10 ⁶ kW.h
Water	320 ML
Fuel oil	3,900 t
Chemicals	18,000 t

In addition construction and operation of the proposed rare earth processing plant would require other quantities of energy in the form of materials, liquid fuels, machines, equipment and human resources over the life of the plant. Energy would also be expended both in producing the materials needed for construction, and during the construction work itself. The amounts of each type of energy are unquantifiable due to the large number of variables such as the number of sources of feedstock and chemicals and routes traversed. Nevertheless, the plant would require in the order of 0.7 ML/a of liquid fuels for the transport of materials to and from the site.

The proposed rare earth plant also has some energy conservation measures of economic benefit. The proposal as a whole would utilize existing buildings, facilities and infrastructure presently lying idle thereby saving capital expenditure at another location. The proposed alkaline process used in separating the rare earths is also the most efficient process commercially available. Heat exchangers and steam circulation would also be used to maximize efficient use of energy, and 5 ML/a of water would be recycled in the process. In addition, conservation features of the existing buildings include a north orientation, natural rooflighting and ridge ventilation in the powerhouse, large factory and warehouse, vertical sun controls louvres on the west face of the warehouse, and anti-heat dome lights in the office building.

6.5 SOCIAL AND ECONOMIC EFFECTS

The substantial social and economic benefits for Australia, New South Wales and the Lismore region were outlined in Section 4.3. The economic benefits would be of direct importance to the Australian and New South Wales economies. The Lismore region would benefit through gains in employment, expansion of the industrial base and flow-on effects from employment and capital investments.

The social impacts of the rare earth processing plant would be related indirectly to the economic effects and would be locally based. As most of the workforce would be expected to be currently resident in the Lismore region there would be no increases in demand for community, private and public facilities. In particular, there would be no special requirements or increased demands for medical, housing, recreational, retail, educational, public order and social welfare facilities. There would be some small increases in demand for particular services and requirements for public facilities. Operating personnel in public facilities such as fire, police and ambulance services would need to be briefed on emergency procedures related to the proposed rare earth processing plant. In addition, there may be a heightened awareness in Lismore on radiation matters. However, it would be recognized that the proponent would be incorporating protection measures into the design of the plant and adopting appropriate management procedures in the operation and decommissioning of the plant (see Sections 6.7.3., 6.8.3, 6.9.4 and 6.10.3).

6.6 TRAFFIC AND TRANSPORT EFFECTS

Access to the proposed rare earth processing plant is via the Lismore to Kyogle Road and Rifle Range Road. Access to the site is considered adequate as the previous site user was required by Lismore Council to seal Rifle Range Road from the Lismore to Kyogle Road to the main gate for a width of 7 m and upgrade the intersection. The site would be serviced by road transport for supply of feedstock, process chemicals and other materials into the proposed plant and rare earth products and by-products out of the proposed plant. There is provision on site to provide a future railway siding if required for transporting of feedstock, process chemicals and products. Public transport services are not considered necessary for the site and most transport movements to and from the site over the project life would be via private road transport.

The latest available average daily traffic volumes (1982) near the site are outlined in Section 5.8. These volumes would have included traffic movements to and from the site when the brewery was operational. Traffic movements to and from the brewery (supplied by the brewery operator) averaged around 450 vehicles per operating day, the majority of which was staff cars with about 75 heavy (3-22 t) vehicles. Hence the traffic generated by the brewery represented about 20% of the annual average daily traffic along the Lismore to Kyogle Road. As the brewery is no longer operational, land owners abutting the site may notice an increase in traffic volumes. The traffic that would be generated from the proposed rare earth processing plant is shown in Table 6.2.

These 250 vehicles, or 500 traffic movements per week to and from the proposed rare earth processing plant, represent about 5% of the annual average daily traffic along the Lismore to Kyogle Road. About 20% of the traffic generated would be heavy vehicles. The total traffic generated by the proposed rare earth processing plant and the number of heavy vehicles would be significantly less than that generated by the previous site user.

Internal access roads within the site, with the addition of the proposed internal access road to the waste repository, would be able to accommodate all traffic movements. There is adequate provision for on-site parking as the 78 car spaces plus visitor's car parking area is well in excess of Lismore Council's requirement of 30 car spaces or 1½ car spaces per employee. Existing car parking provisions would also provide for some further development of the site. If additional car parking provision were required by Lismore Council in the future then the

hardstanding storage area east of the large factory could be utilized. A large covered loading dock attached to the large factory is considered adequate for the proposed rare earth processing plant and associated industries upon full development of the site. Adequate provision has been made on site for access, loading, unloading, manoeuvring and parking of vehicles.

Table 6.2 Traffic generation from the proposed rare earth processing plant

Traffic sources	Annual Requirement t/a	Traffic generated per operating week
Feedstock	2,000	4 x 10 t trucks
Chemicals	18,000	18 x 22 t semi-trailers
Fuel oil	3,900	4 x 22 t semi-trailers
Sand	500	1 x 10 t truck
Drums/barrels	50	1 x 2 t truck
Rare earths	1,100	3 x 10 t truck
Trisodium phosphate	1,200	3 x 10 t truck
Ammonium sulphate	3,900	9 x 10 t truck
Thorium residue	865	1 x 22 t truck
Staff	-	140 cars
Visitors	-	say 36 cars
Miscellaneous (couriers, sales representatives, rubbish collection)	-	say 30 cars and trucks
Total		250 vehicles (say 205 cars and 45 trucks)

6.7 WASTEWATER DISPOSAL

6.7.1 Radioactive character of wastewater

The annual wastewater volumes to be produced by the process are given in Figure 2.2. The primary consideration underlying the design of wastewater treatment is the level of radioactivity in the seven wastewater streams. Assessment of these levels has been made using data from bench testing of monazite processing conducted by O'Connor and Chang for Kinhill Stearns (1985). Only wastewater streams 1, 2 and 7 would need to be considered in terms of their radiological impact as wastewater streams 3, 4, 5 and 6 are free of radioactivity.

Wastewater 1 would be the condensed water vapour from the monazite digestion and cracking stage. The radioisotopic character of the water would alter within

several days of formation while radioactive equilibrium was being established. The activity would then be dominated by lead-210 (half-life of 19 years) and would therefore decay slowly during subsequent decades.

Wastewater 2 is the wash water from filtering of the rare earths, thorium and uranium hydroxides formed during phosphate removal. The work of O'Connor and Chang (Kinhill Stearns 1985) showed that the uranium, thorium and radium nuclides pass preferentially into solution giving the water essentially permanent activity, but at levels below the relevant public derived limits (PDLs) as described in Section 6.7.2.

Wastewater 7 would also have activity that would be in the vicinity of the PDL values for the radium isotopes and for lead-210. As the volume of wastewater 7 would comprise 61.5% of the waters entering the waste treatment plant, the activity of wastewater 7 would have a greater influence on wastewater disposal strategy than wastewater 2, which would account for only 12.3% of the total volume.

6.7.2 Disposal strategy

The wastewater handling system is described in Section 2.10. The principal design criterion is the need to ensure that activity levels in discharged water would meet standards for potable water prescribed for the general public. These standards would be met by diluting the water prior to discharge into the South Lismore sewage treatment works. The critical radionuclides influencing dilution requirements are lead-210 and radium-226. Table 6.3 gives the estimated activities for these radionuclides in the wastewaters entering the on-site waste treatment plant according to data derived by O'Connor and Chang for Kinhill Stearns (1985).

Table 6.3 Estimated activity levels for wastewaters entering the waste treatment plant

Radionuclide	Concentration (C) Bq/m ³	Public derived limit (PDL) Bq/m ³	Ratio (C/PDL)
Lead-210	3.1×10^3	1.0×10^3	3.1
Radium-226	2.6×10^2	1.0×10^2	2.6

The PDLs are taken from Schedule II of the New South Wales Radioactive Substances Regulations (1959). The PDL represents the permissible concentration of the stated radionuclide in drinking water in the absence of other radionuclides. The ratio concentration/PDL represents the dilution factor for a given radionuclide to ensure compliance with the Regulations. For simultaneous exposure to a number of radionuclides, the Regulations allow the use of a multiple exposure index for estimating dilution requirements such that the sum of the concentrations/PDLs is <1. As the waste treatment plant has sufficient capacity to provide over nineteen fold dilution, the proponent has surplus capacity to ensure adequate environmental safeguards. The proposed dilution factor of the wastewaters is 9.8 times the inflow providing a safety factor of 1.7 times the required PDL. In addition there are PDLs for insoluble natural thorium and uranium in water of 1×10^5 Bq/m³ and 2×10^5 Bq/m³ respectively. The calculated annual loadings include 13 kg of thorium and 0.68 kg of uranium for a maximum designed filtration loss of 0.01% of residue.

These loadings correspond to concentrations in diluted wastewaters of 3.3×10^3 Bq/m³ for thorium and 5.2×10^2 Bq/m³ for uranium respectively. These concentrations in turn correspond to only 3.3% and 0.26% of the respective PDLs. When allowance is made for some dissolution of the thorium and uranium, the predicted concentrations also comply with the PDLs.

The diluted wastewaters represent a flow of 320 ML/a from the waste treatment plant that was the licensed discharge from the brewery. Hence the proposed wastewater flow from the plant would be less than the PDL requirements and would impose no greater operational requirements on the South Lismore sewage treatment works compared to the former site user.

Correspondence with the State Pollution Control Commission (Appendix E) has stated that if the proposal accords with the requirements of the Radioactive Substances Act, 1957 and Regulations (1959) then additional requirements under the Clean Waters Act, 1970 will not be applied unless called up by the Department of Health. In addition, the waste treatment plant, either in its present or modified form, would be able to meet other physical, chemical and biological standards set by Lismore Council prior to discharge to the South Lismore treatment works. The loadings of the wastewaters as shown in Table 2.6 for acceptance in the South Lismore sewage treatment works would be subject to consultation between the proponent and Lismore Council. If these quantities in the wastewater stream cannot be accepted by the treatment works then on site treatment would be undertaken with recovery rates so that the effluent discharged would meet the standards of Lismore Council. Acceptance criteria specified to date comprise a pH range of 7-9 and maximum levels of 300 mg/L five day biological demand, 300 mg/L suspended solids and 35 mg/L oil and grease. An oil and water separator exists in the powerhouse and the existing waste treatment plant would be able to discharge wastewaters within the above parameters.

6.7.3 Safeguards

The site has a number of existing safeguards for handling wastewaters. Separate wastewater and stormwater collection systems ensure no cross contamination. The wastewater collection system has floor drains with protective grating that discharge through trapped and water sealed sumps to the waste treatment plant. The waste treatment plant could handle over nineteen times the proposed volume of process wastewaters and twice the proposed volume of process wastewaters including dilution waters. The concentration and activity levels of the discharged wastewaters would be well under the prescribed limits of all relevant legislation. The proponent would install a number of additional safeguards. A back-up oil fired power system would be installed in the powerhouse to provide power for the proposed plant in the event of an electricity power failure. This would ensure continued operation of the waste treatment plant. A back-up diesel pump would also be installed in the waste collection pit. In the unlikely event of a malfunction of both pumps (electric and diesel) the trade waste would normally overflow into the stormwater system. However, if the waste collection pit started to fill because of these malfunctions the proponent would continue pumping the waste to the waste treatment plant using a portable petrol driven pump. As a further safeguard the proponent would install an automatic shutdown control system in the waste collection pit. One system under consideration is a three-level probe that would operate so that a low-level probe activated a back-up pump, a middle level probe alerted a control panel in the office so that the portable pump would be operated as another back-up pump, and a top level probe that automatically switched the processing plant off.

The proponent would also install an automatic radiation monitoring meter in the waste treatment plant with an alarm connected to a control panel in the office.

The meter would constantly monitor the radiation characteristics of the wastewaters before discharge to the sewer. In the unlikely event that the prescribed concentration or activity levels for the diluted wastewaters were exceeded, the alarm would enable all discharge from the waste treatment plant to be stopped. Under normal operating conditions, the waste treatment plant would have a surplus capacity of 0.76 ML/d equivalent to receiving 18 hours of wastewater from the rare earth processing plant. This time would enable any fault to be rectified and the wastewaters diluted to the PDLs before discharge. All these safeguards are considered adequate to meet legislative and Lismore Council requirements and any unforeseen events such as power failures. The activity data employed for planning purposes would also be validated in an intensive study during the commissioning of the proposed plant and routine monitoring of water quality would be performed over the life of the project.

In addition, consideration would periodically be given to the radioactivity levels (particularly PDLs) in various parts of the environment by the NHMRC, who then issue Codes of Practice for guidance. State Governments may in due course incorporate these Codes within their Regulations. In the event that a change was made in the future to the New South Wales Radioactive Substances Regulations (1959), and that, as a result, the wastewaters discharged from the proposed plant did not meet the new Regulations, the proponent would apply for an appropriate discharge licence from the State Pollution Control Commission and would comply with whatever requirements were necessary at that time.

6.8 SOLID WASTES DISPOSAL

6.8.1 Radioactive character of wastes

The radioactive solid material produced by the process would be almost entirely confined (over 99.99% extracted with the remainder contained in the diluted wastewater) to the thorium residue which would be recovered by filtration following cracking of the feedstock. The quantities, physical state and chemical composition of the residue are described in Section 2.6.2 and Table 2.2. The characteristics that determine disposal strategy for the residue are the level of gamma radiation emanating from the residue and the possibility of migration of radionuclides from the residue to the aquatic environment, especially to potable water. The residue would be designated as low specific activity radioactive waste under the relevant Codes of Practice for disposal purposes.

Permanent storage of the residue would require sufficient radiation shielding to reduce gamma radiation flux in the vicinity of the site to acceptable levels. One method would be to provide a cover of several metres of soil, or shallow land burial that would reduce radiation doses at the disposal site to background radiation levels. However, the possibility of groundwater contamination is a more critical consideration and site selection should ensure that the residue is effectively isolated from water or that the rate of transfer of radioactive material to water is negligible.

The proponent has been unable to nominate a permanent storage site for radioactive solid wastes as a Commonwealth-State Consultative Committee initiative on the selection of suitable sites has not been completed. This Committee is discussing permanent storage sites and a decision is expected shortly. Interim on-site storage has therefore been proposed, pending the outcome of the inter-government planning. The proposed interim waste repository is described in Section 2.10.

6.8.2 Radiation hazards

The interim solid wastes repository has been designed to isolate the material from the immediate environment. The safeguards described in Section 6.8.3 are designed to prevent the release of radioactive material from the waste repository over the lifetime of the project, prevent any contamination of water and limit public access to the site.

Gamma radiation levels near the interim waste repository requires that appropriate occupational health measures be implemented within the confines of the site (Section 6.10). However, the incremental gamma radiation levels from the interim waste repository at the boundary of the site on Rifle Range Road would be approximately 0.03 $\mu\text{Sv/h}$ which is within the range of existing background gamma radiation levels onsite.

6.8.3 Safeguards

The plan for the interim waste repository (Figure 2.6 and Section 2.10) has been designed to accommodate in three stages all the low-level radioactive residues generated over 10 years' operation of the rare earth processing plant. The main features of the interim waste repository include reinforced concrete bins to absorb gamma radiation, prevention of contamination of surface and groundwaters and no public access to the site.

The steel containers, packing sand and concrete walls, floor and roof of each bin would absorb most of the gamma radiation produced by the contained residues. The gamma radiation levels at the site boundaries would be checked during regular on-site monitoring as required by relevant legislation and Codes of Practice. If the gamma radiation levels approached any PDL then action would be taken to reduce the levels. This would be achieved by either thickening the concrete bins or adding a surrounding skin of lead shielding or adding bricks or concrete. As the Stage 2 waste repository extension would be closer to Rifle Range Road than the other two stages, increased shielding composed of 800 mm thick concrete walls would be required.

Surface and groundwaters would not be contaminated by the migration of radionuclides from the residues. Each bin would have joint free reinforced concrete walls, floor and roof that repel stormwaters. Drums or barrels filled with residue would be stacked inside each bin and surrounded by packing sand for stability, absorption of leaks and support of the roof. The steel drums or barrels would not leak as the residue is in the form of a gel. In the unlikely event that a drum or barrel did leak, the packing sand would absorb the gel and any excess gel would drain to the bin floor. Each bin would have a valve and covered drainage outlet (normally closed) that could be released to drain to a sump below. If liquids did enter the sump upon release of any of the valves they would be pumped to a drum or barrel for restorage in a bin. Each bin would have a protective overhead roof while it was being filled and a concrete roof with waterproof membrane would be installed when filling was complete. Each stage of the repository would also have protective drains for the diversion of stormwater into the weir. A sampling sump would be installed in the weir and the sump would be monitored regularly to check on the radiation levels of collected water. In addition, the interim waste repository would be constructed over a pressure aquifer confined by a clay layer of variable thickness so that contamination of groundwater through spillage or leakage of the residue would be extremely unlikely.

The interim waste repository, weir and sampling sump would also be security fenced by extending the existing 2.3 m high security fence around the adjacent waste treatment plant. The controlled access area would also be enclosed by the security fence. The gate to the interim waste repository site would be locked and another locked gate would be installed on the access road to the repository on the site boundary. Trefoil (radiation warning) signs would be installed on both gates and the security fencing. Hence, members of the public could only gain access to the waste repository site by ignoring the trefoil signs, trespassing on private lands and circumventing two locked gates, a security fence and 24 hour operation of the plant. In the unlikely event that a member of the public did gain access to the confines of the waste repository site they would need to scale 3.6 m high concrete walls in order to remove a drum containing approximately 600 kg or barrel containing 250 kg of residue. The residue within each barrel would be non-fissionable and of no commercial value to members of the public. In addition, a person would have to stand 1 m away from the barrel or drum filled with residue for 150 hours or 100 hours respectively in order to receive a dose equivalent to one 0.2 mSv diagnostic X-ray.

The interim waste repository would have adequate safeguards to protect the environment and public by absorbing gamma radiation so that off site levels were safe, surface or groundwaters were not contaminated and public access was denied.

6.9 ATMOSPHERIC EMISSIONS

6.9.1 Radioactive emissions

Potential atmospheric emissions from the plant can be classified as radioactive and non-radioactive. Neither category would have a significant impact on the environment, public health or radiation worker health.

Radioactive emissions would arise predominantly from any monazite and xenotime dust particles discharged from the receiving hopper into the atmosphere and from the radioactive daughters of the gaseous isotopes thoron (radon-220) and radon (radon-222) which would be released from the grinding mill. There would also be some release of thoron and radon gas from the waste treatment plant.

Thoron (half-life of 52 seconds) decays rapidly to the relatively long-lived isotope lead-212 (half-life of 11 hours) which in turn decays to other daughters. Radon decays more slowly (half-life of 3.6 days), forming a series of radioactive daughters which include the long-lived isotope lead-210 (half-life of 19 years). The health hazards associated with exposure to thoron, radon and their daughters derive mainly from inhalation of the alpha-emitting daughters. Levels of monazite and xenotime dust and of the daughters of thoron and radon would readily meet the PDL standards specified in the relevant regulations and Code of Practice as detailed in the following paragraphs.

Hazards due to monazite and xenotime dust inhalation are attributed to the alpha-emitting isotopes in the thoron-232 and uranium-238 decay chains. The PDL standard adopted for atmospheric levels of monazite and xenotime has been derived from the values for natural uranium and thorium in the New South Wales Radioactive Substances Regulations, namely $2 \times 10^{-2} \text{ Bq/m}^3$ and $1 \times 10^{-3} \text{ Bq/m}^3$ respectively. The corresponding calculated PDL for inhalation of monazite and xenotime is approximately $5 \mu\text{g/m}^3$, and for radiation workers the derived limit is approximately $15 \mu\text{g/m}^3$. The proponent would ensure compliance within these limits by minimizing dust emission through the safeguards outlined in Section 6.9.4.

Thoron and radon daughter concentration derived limits are not specified in the New South Wales Radioactive Substances Regulations (1959). The limits adopted by the proponent in preparing the EIS are those from the Commonwealth Code of practice on radiation protection in the mining and milling of radioactive ores, 1980. Prediction of daughter concentrations has been made using the bench data, and methodology and model developed by O'Connor and Chang for Kinhill Stearns (1985) and on the following assumptions:

- . 260 kg/h of monazite would be milled using continuous or batch operation;
- . the mill room would be sealed from the remainder of the small factory;
- . the volume of the mill room would be 210 m³;
- . the air in the mill room would be ducted to the atmosphere at a rate of 20 changes of air per hour;
- . air leakage from the mill would be 10% of the volume of the mill per hour.

The model predicts levels of thoron and radon daughters in the mill room of 0.0012 working level (WL) units and 0.0005 WL for thoron and radon daughters respectively. These estimates are far below the derived limits from the above Code of Practice for a designated employee, namely 3.3 WL and 0.33 WL respectively. On the basis of a WL safety factor of 2,750 times for thoron daughters and 660 times for radon daughters it could be concluded that daughter concentrations in the mill room would be acceptable for radiation protection of workers with ventilation of the mill room. In keeping with the ALARA principle, the mill room would be sealed from the remainder of the small factory to prevent any accumulation of daughter levels in the small factory and mill room air would be changed 20 times per hour and ducted to the 52 m high stack for discharge to the atmosphere. A further benefit of ducting the air would be that thoron and radon daughters would be inhibited from lodging on surfaces such as the walls of the mill room or clothing.

In comparison with the PDLs for thoron and radon daughters from the above Code of Practice (0.1 WL and 0.01 WL respectively), the predicted concentrations in the mill room ventilated air would have a WL safety factor of over 80 times for thoron daughter and 20 times for radon daughters. It is therefore concluded that daughter concentrations would have no significant environmental impact for short-term exposure. Long-term exposure is examined in Section 6.9.3.

6.9.2 Non-radioactive emissions

At the digestion and cracking stage of the proposed treatment process, condensed vapours would be emitted along with wastewater stream 1. The bench scale test work of O'Connor and Chang for Kinhill Stearns (1985) has shown that the carry through of gases past the condenser for wastewater stream 1 would be negligible and would have minor environmental impact. These emissions would disperse via the 1.5 m high ridge vent on the roof of the small factory. Water vapours and carbon dioxide would also be emitted during the process and during discharge of wastewaters but would disperse freely within the large internal areas of the small and large factories. Solvent vapours in the large factory would either be dispersed freely or ducted to meet any regulations.

The two-oil fired boilers in the powerhouse would also emit air pollutants, in particular sulphur dioxide and oxides of nitrogen. Each boiler is connected to separate flues within the 52 m high stack. Calculations have shown that the

stack height is more than adequate to meet the design criteria of the State Pollution Control Commission for the dispersion of sulphur dioxide and oxides of nitrogen.

6.9.3 Dispersion of emissions

Three of the four existing flues in the stack would be utilized in the proposed rare earth processing plant. Two flues would discharge gases from the oil fired boilers to the atmosphere. The third flue would discharge the mill room air containing thoron and radon gases at concentrations significantly below the PDLs. Modelling of the discharge of radon and thoron daughter emissions from the three flues has shown that assuming a worst case condition of no plume rise and continual exposure to the maximum ground level concentrations, annual limits for radon and thoron daughter exposure (as given in the Code of Practice) would be easily met. Actual exposure would be much lower than figures predicted from this analysis and would therefore not represent a risk to public or occupational health.

6.9.4 Safeguards

Safeguards would be designed to reduce monazite and xenotime dust and the daughters of thoron and radon to acceptable levels. Control measures for minimizing dust emissions through the use of enclosed skirtings from feedstock delivery containers, and the use of enclosed conveyors with attached dust extraction unit are detailed in Section 2.9. The use of wet grinding and sealed machinery would eliminate the possibility of further dust emissions. In addition, the proponent would accommodate relevant provisions under the Commonwealth Government draft guideline on Implementation of dust control strategies in the mineral sands industry that includes measures for ventilation, dilution, protective equipment, housekeeping and education. The safeguards for daughter concentrations were described in Section 6.9.1 and include sealing of the mill room, changing the mill room air 20 times per hour and ducting the air to the atmosphere via a 52 m high stack. An additional measure would be the use of wet-handling for the thorium residue to ensure that residue particles were not entrained in the atmosphere. All atmospheric emissions would be significantly below the PDLs and worker and public health would not be at risk. An extensive monitoring programme would also be performed by the proponent during the commissioning stage to measure levels of radon and thoron in air and uranium, thorium and radium in soils and water. The key locations would be the receiving hopper, the grinding mill in the small factory, the duct from the mill room, the thorium residue filtration area in the small factory, the waste treatment plant, and a selection of locations in close proximity to the small factory. The plant would be shut down if prescribed regulations and standards were exceeded at any time.

6.10 HEALTH AND SAFETY

6.10.1. Worker health and safety

Workers associated with the proposed rare earth processing plant might be exposed to internal and external radiation doses from the sources outlined in Section 3.2. The principal sources of radiation from the proposed rare earth processing plant with effects and controls are detailed in Table 6.4.

Table 6.4 Principal sources of radiation from the proposed rare earth processing plant

Source	Effects and controls
Unloading of feedstock	
Internal exposure	Negligible as the feedstock handling system has been designed to reduce transfer of feedstock particles to the atmosphere.
External exposure	Gamma flux near the receiving hopper would require barrier protection and the receiving hopper would be classified as a controlled area.
Feedstock transit silo	
Internal exposure	Negligible as the silo is sealed.
External exposure	Gamma flux near the western transit silo would require barrier protection. An area within 3.0 m of the silo would be classified as a controlled area and an area within 15.0 m of the silo would be a supervised area.
Grinding mill	
Internal exposure	Negligible within the mill room as the mill is sealed to prevent release of thorium and uranium particulate matter. Levels of thoron and radon daughters within the mill room would be insignificant.
External exposure	Gamma flux from the grinding mill would require barrier protection. A 2.8 m area around the mill would be classified as a controlled area.
Reactor vessel	
Internal exposure	Negligible within the small factory as the reactor vessel is sealed for elevated temperature and pressure which also prevents the release of thorium and uranium particulate matter. Levels of thoron and radon daughters within the small factory would be insignificant.
External exposure	Gamma flux from the reactor vessel would require barrier protection. A 2.8 m area around the vessel would be classified as a controlled area.

**Phosphate and thorium residue
filtration units**

Internal exposure

Negligible as the filtration units are sealed to prevent release of thorium and uranium particulate matter. Levels of thoron and radon daughters within the small factory would be insignificant.

External exposure

Gamma flux from the filtration units would require barrier protection. A 2.8 m area around the filtration units would be classified as a controlled area.

**Transfer of residue from small factory
to interim waste repository**

Internal exposure

Negligible as drums or barrels would be automatically sealed.

External exposure

Gamma flux from the drums or barrels would require part of the small factory to be classified as a controlled area, and the access roads between the small factory and repository would be classified as supervised areas.

Interim waste repository

Internal exposure

Negligible as drums or barrels would be sealed.

External exposure

Gamma flux would be reduced to acceptable levels through attenuation of packing sand, concrete shielding and distance. Surrounds would be classified as a controlled area for 3.2 m and security fenced. Area within 43 m would be a supervised area.

Waste treatment plant

Internal exposure

Release of thoron and radon daughters to the atmosphere. Surrounds would be classified as a controlled area and security fenced.

External exposure

Negligible gamma flux from wastewaters.

The proposed rare earth processing plant would also be designed and operated according to the design criteria listed in Table 6.5. The criteria have been developed to ensure that the provisions of the New South Wales Radioactive Substances Act, 1957 and the Commonwealth Code of practice on radiation protection in the mining and milling of radioactive ores, 1980 are met. Compliance with these provisions would ensure that employees and the general public are protected at all times.

Table 6.5 Radiation protection design criteria

Exposure	Value	Relationship to radiation protection standards
Total annual exposure from all sources		
Designated employees	50 mSv/a ⁺	Annual dose equivalent limit
Other employees and areas accessible to general public	5 mSv/a 1 mSv/a lifetime average	Annual exposure limit
External exposures (gamma exposure)		
Designated employees	25 mSv/a ⁺	50% of annual exposure limit
Other employees and areas accessible to general public	0.3 µSv/h above background levels	50% of PDL
Material in transport		In accordance with <u>Code of Practice for the safe transport of radioactive substances</u>
Internal exposures (atmospheric contamination)		
Designated employees	350 Bq of total activity per annum ⁺	25% of annual limit of intake *
Other employees and areas accessible to general public	35 Bq of total activity per annum	25% of annual limit of intake *
Thoron and radon daughter exposures		
Designated employees	Thoron 10 WLM/a ⁺	25% of annual exposure limits
	Radon 1.0 WLM/a ⁺	25% of annual exposure limits
Exposure rate in areas accessible to other employees and the general public	Thoron 1.0 WLM/a	25% of public derived limits
	Radon 0.1 WLM/a	25% of public derived limits

* Annual limit of intake for thorium-232 and uranium-238 mixture in equilibrium with their daughters assuming a thorium/uranium mass ratio as in monazite.

+ Overall exposure for designated workers would be restricted by limiting the contribution from all sources taken together.

The proponent would meet all relevant provisions under State Legislation and Commonwealth Codes of Practice (including revisions) to ensure maximum protection was afforded to the public, workers and the environment from any emissions resulting from the operation of the rare earth processing plant. The radiation protection design criteria in Table 6.5, and safeguards for the proposed rare earth processing plant, would ensure that all public health and safety criteria would be satisfied.

6.10.2 Public health and safety

The measures and safeguards described in Sections 6.7.3, 6.8.3, 6.9.4 and 6.10.3 have been designed to ensure that external exposure to gamma radiation at the perimeter of the proposed rare earth processing plant, and the radioactivity levels in wastewaters and atmospheric emissions would meet all relevant provisions of the New South Wales Radioactive Substances Act, 1957, Radioactive Substances Regulations (1959) and the Commonwealth Code of practice on radiation protection in the mining and milling of radioactive ores, 1980. Many of the requirements under the above legislation and Code of Practice were designed to protect the health and safety of both workers and the public. All residents within the vicinity of the site, including those within 2 km of the centre of the site, would not be harmed in the short term or long term by any radioactive emissions (including wastewaters, radon and thoron gases and gamma radiation) from the proposed plant. The emissions from the proposed plant into the air and water would be significantly below the limits specified in the relevant New South Wales Legislation. The above Code of Practice is more specific than the New South Wales Legislation in detailing methods and levels of worker and public protection.

In addition, the chemicals storage bund shown in Figure 2.3 has been designed so that all chemicals on site would be safely stored and handled by employees as required under the New South Wales Dangerous Goods Act, 1975 and Dangerous Goods Regulation (1978). The bunding would accomodate 100% of the spillage from the largest tank and 25% of the spillage from all the tanks. The stopcocks located on each bund would allow all storm waters to be drained to the stormwater system. The oil storage tanks are already installed within a safety bund.

6.10.3. Safeguards

Protective measures have been carefully developed to meet the design criteria in Table 6.5. A feature of these measures is the need to establish controlled areas in locations where gamma radiation levels and airborne concentrations of thoron and radon daughters are likely to be significant. The confines of the controlled areas and surrounding supervised areas have been established by gamma dose modelling calculations and using data from the work of O'Connor and Chang for Kinhill Stearns (1985). The safeguards that would be adopted in the proposed rare earth processing plant are listed below:

- Controlled areas would be established to include the receiving hopper, grinding mill, reactor vessel, phosphate and thorium residue filtration units, thorium residue handling and waste repository facilities and the waste treatment plant. Controlled areas would only be accessible to designated employees.
- The controlled areas would be separated from other operational sections of the rare earth processing plant by the use of barriers such as walls or fences. In practical terms, all of the receiving hopper, small factory and waste treatment and waste repository security fenced areas would be controlled areas.

- . Supervised areas would be established to include all access roads (including the proposed internal access road) between the small factory and the interim waste repository, and an area within 60 m of the waste repository. In practical terms, the whole site would be a supervised area and members of the public would have to report to the gatehouse for access to the security fenced rare earth processing plant.
- . Handling of material such as feedstock and residue would be avoided to minimize air contamination. In particular, wet milling of the feedstock and disposal of the thorium residue as a gel are important aspects of plant design.
- . Process equipment located in controlled areas would be designed for remote operation to minimize potential exposure times.
- . The process would be designed to be fully enclosed to minimize potential for spillages.
- . Monitoring equipment and alarms would be installed on the process equipment, and within the small factory to measure radiation levels.
- . Where necessary, equipment containing bulk quantities of radioactive material would be shielded to reduce exposure rates.
- . Equipment in controlled areas would be selected and designed for reliable operation and ease of maintenance.
- . Surge bins would be installed between stages of the process in case of malfunction and to facilitate maintenance.
- . Floor surfaces in controlled areas would be non-absorbent and easy to clean.
- . Facilities would be provided for easy and regular washing of floors and equipment. All washings would be discharged to the waste treatment plant via floor drains and sumps.
- . A truck washing area would be provided next to the receiving hopper and washings would be diverted to the trade waste collection system.
- . Operator access to the controlled areas within the small factory would be via a change room.
- . Protective equipment and clothing would be issued to workers where required.
- . Designated employees would undergo induction training, including operating, handling, safety and emergency procedures.
- . During operation of the rare earth processing plant, gamma and airborne radiation levels on site and from the surrounding areas would be monitored regularly over the plant life. As the radiation protection assessments in this EIS are based on test data and best available knowledge, they would be verified during extensive monitoring of airborne radioactivity levels in initial operation of the plant.
- . Further baseline radiation level sample surveys would also be undertaken during the pre-operational phase of the plant in order to meet the

requirements of the monitoring programmes of the Code of practice on radiation protection in the mining and milling of radioactive ores. This sampling would include selected measurements of radioactivity in air, watercourses, crops and locally produced food products including levels of uranium, thorium, radium and gamma radiation. The monitoring programme would be regularly updated as required by the Codes of Practice and Legislation.

- . The health of employees would be monitored in accordance with the provisions of the Radiation Substances Act, 1957 and Commonwealth Codes of Practice. The monitoring programme would incorporate the following and any additional provisions as required by the New South Wales Health Department. All employees would undergo pre-employment and termination of employment medical examinations. Other medical examinations would be undertaken at regular intervals and the results of all medical examinations would be advised to the employee. All designated employees would be required to wear film badges for monitoring gamma radiation.
- . Trefoil signage would be installed on the access gates and security fencing surrounding the interim waste repository and waste treatment plant area, the small factory and receiving hopper.

The radiation exposures to employees and members of the public would be limited to as low as reasonably achievable, (ALARA principle) with social and economic factors being taken into account. At all times, operation of the proposed plant would be in accordance with provisions of relevant Legislation and Codes of Practice.

6.11 RISK ASSESSMENT

6.11.1 Areas of potential hazard

A preliminary risk assessment for the proposed rare earth processing plant has identified the main hazards as fire, explosion and release of chemicals and radioactive substances both on site and off site. These hazards could be caused, for example, by vessel failure, pipeline fracture, spillages, leaks, poor operational practice and maintenance, vehicular accidents and failure of equipment, processing plant and infrastructure. In addition, environmental risks related to chemical processes, agricultural output and oceanographic and coastal environments have been identified separately by Lismore City Council and the Department of Environment and Planning. As the rare earth processing plant would be designed to meet all safety and legislative requirements while incorporating new plant, equipment and safeguards, with trained personnel for safe operations, there would be only a small likelihood and low risk that the hazards would actually occur. In the event of any such occurrence, most of the effects would be restricted to the site and remedial measures could be implemented. Table 6.6 shows the main areas of potential risk associated with each hazard.

There would be a small risk of fire or explosion within the proposed chemicals storage bund owing to the characteristics of the chemicals to be stored on site. The chemicals storage bund area has been designed in accordance with the safety criteria detailed in the New South Wales Dangerous Goods Regulations, so that selected chemicals are banded separately and chemical spurts and spillages would be contained within the bunds. These design criteria help ensure that the risks of fire and explosion would be minimized. In addition, these risks would be further reduced as the proposed bund area would be physically separated from

Table 6.6 Areas of potential risk

Hazard	Area of potential risk
Fire	Chemicals storage bund Small and large factories
Explosion	Chemicals storage bund Powerhouse
Release of chemicals	Transport of chemicals Chemicals storage bund Chemical processes in small and large factories Pipelines between chemicals storage and small and large factories.
Release of radioactive substances	Transport of feedstock Receiving hopper Small factory Interim waste repository Waste treatment plant Agricultural output in vicinity of site Oceanographic and coastal environments

other buildings on site and the chemical process, the bunding would be protected from vehicles by kerbing, reactive chemicals would be received in liquid form, fire services are readily available on site, the quantities stored on site would be as small as economically possible to operate the plant, and access to the proposed rare earth processing plant, and hence the chemicals storage area, would be controlled. Any spills in the banded area would be contained in the bund and pumped out into suitable containers for reuse in the process.

The materials used for storage vessels and piping would also be chosen for their resistance to corrosion. The proponent would also meet any further requirements of the Dangerous Goods Branch of the Department of Industrial Relations such as vapour vents for tanks within the proposed chemicals storage bund. Any release of chemicals from pipe transfers between the storage area and the small and large factories would be diverted to the trade waste collection system for treatment and dilution. Isolation valves would be installed at the ends of all chemical pipelines so that in the highly unlikely event of a major leak or rupture in a chemicals pipeline the valve could be closed to minimize spillage.

There is also a small risk of fire within the small and large factories because of the characteristics of the chemicals involved. However, the process in both the small and large factories would be designed to minimize all risks through good design, selection of appropriate equipment, sound operational practices, and the use of monitoring equipment and safeguards. The proponent would install additional foam extinguishers in the large factory near the higher risk solvent extraction area as a further safeguard to supplement existing fire systems.

There is also a very small risk of explosion in the powerhouse because of the boiler operations. The existing boilers are rated to 3,950 kg/h but proposed operation would be 500 kg/h. Hence the boilers would not be operating near capacity and risk of explosion would be reduced.

Compared to the very small risk of fire or explosion within the plant there would be a relatively larger risk of minor spills caused by accidents or incorrect loading and unloading of chemicals that would be contained in the bund, diluted and discharged to the waste treatment plant.

The actual routes for transport of materials by truck to and from the site have not been disclosed for commercial reasons but they would be along designated main roads and State highways. All materials would be transported in accordance with State and Commonwealth transport regulations including the Australian code for the transport of dangerous goods by road and rail, the Code of practice for the safe transport of radioactive substances, 1982 and the New South Wales Dangerous Goods Regulation (1978). These Codes and legislation provide for the safe transport of dangerous chemicals and radioactive substances so that risks are reduced. Any additional special procedures in handling these materials would have to be issued by the appropriate authority. The proponent, through Currumbin Minerals, has had extensive experience in transporting monazite feedstock in Queensland with annual travel over 1.4 million km. In the past 5 years there have been one minor and one major accident with no fault being attributed to the driver by the police, and no spillage of the load. This would indicate that there is very low risk in transporting monazite. The Queensland Department of Health issues licences covering transport of monazite with working rules (reproduced below) to minimize risk. The proponent would meet any similar or special procedures issued by the New South Wales Department of Health together with all other requirements under relevant Codes and legislation.

Queensland Department of Health
Working rules for the transport of radioactive substances as full loads

1. Radioactive substances in the form of mineral sands or their concentrates will be transported only under "full load" conditions. That is, the consignor will have exclusive use of the vehicle, and other materials shall not be transported in the same load.
2. All loads shall be carried from consignor to consignee without undue delays or deviations, re-stowage of loads or trans-shipment.
3. The driver shall ensure that the consignor certifies that each load is offered and stowed in compliance with the requirements of the Code of Practice for the Safe Transport of Radioactive Substances 1982. (This will ensure that radiation levels in and about the vehicle are within prescribed levels).
4. The driver shall ensure that appropriate documentation is received at the loading point.
5. All loads to be tarped.
6. Radiation placards will be fixed front, back and both sides of vehicle. These placards are to be removed when not carrying radioactive material.
7. The driver shall ensure that there will be no leakage of material from the vehicle.
8. The load compartment will be decontaminated before other use by washing out at unloading point. This will include decontamination of tarpaulins.
9. The driver's compartment will be kept clean of any likely contaminants.
10. No passengers, other than authorized employees, will be allowed in the vehicle while carrying radioactive substances.

Minor spillage of feedstock on site would only be likely to occur on infrequent occasions on hardstanding areas. As the monazite has low specific radioactivity, any spillages would be immediately swept up and put in the receiving hopper and the contaminated area hosed down with washings directed to the waste treatment collection system, which has sumps for collection of solids that would be returned to the process. All other releases of radioactive substances on site would be controlled and would be below the relevant PDLs that have been designed to protect both worker and public health and the environment. Any risks associated with the release of radioactive substances on site would be minimized through the safety factors within the plant's design and existing infrastructure, low level activity of the feedstock and proposed safeguards. Although the radioactive emissions from the process have a very low potential for biologically damaging properties the ICRP has adopted radiation protection standards such that radiation risks are compared with other acceptable risks of everyday life (Section 3.3).

Examples of unplanned events resulting in uncontrolled release of radioactive substances on site include a failure in both power systems (electricity and back-up fuel oil), a failure in the waste treatment plant, a fire or malfunction in the equipment in the small factory or failure in the ventilation system. In the unlikely event that these failures occurred despite plant and infrastructure design and safeguards, there would be some short-term localized increase in radiation levels contained on site while the failure was rectified. There would be no increase in off-site radiation levels as the waste treatment plant would have automatic shutdown devices (Section 6.7.3) and radon and thoron gases would be significantly below PDLs with forced ventilation of the mill room. In addition, there is an extremely small risk that acts of sabotage or major natural catastrophes such as cyclones could occur and affect operation of the proposed plant. The incidence of major floods in the vicinity of the site is relatively high and access to the plant could be cut-off on irregular occasions necessitating shut-down of the proposed rare earth processing plant.

Section 6.11.2. outlines the risks associated with the chemical processes in the proposed rare earth processing plant, and external or off-site risks due to release of radioactive substances are discussed in Sections 6.11.3. and 6.11.4.

6.11.2 Chemical processes

The proponent has selected the more efficient alkaline process for the proposed rare earth processing plant rather than the commercially viable acid process which results in a less favourable working environment. The process uses complex but proven industry standard chemical processes that are in safe use in rare earth processing plants outside Australia.

The process involves toxic, flammable, reactive and corrosive chemicals which would require safe handling and use. The chemicals that would be used for the process are common to many industrial plants in Australia. The products and byproducts of the process are non-fissionable and rare earth products would be non-toxic and non-radioactive. Design of the rare earth processing plant and operating practice would conform to the latest Australian standards for handling of chemicals, to ensure worker safety and minimize risk.

All phases of the process would be monitored from a centralized control system that would enable safe shut-down of the plant should this be necessary. Parameters monitored would include levels in tanks, temperature of the process at various stages, flow of all liquids, material density and pH. Product quality would be monitored by sample analysis and substandard material would be recycled. The plant design would also incorporate sufficient surge capacity to

accommodate minor shut-downs. Back-up pumps would be incorporated in the plant to enable appropriate flows to be maintained in the case of failure. Preventative maintenance schedules for the plant would be established. The processing operation also allows for the recovery and recycling of chemicals where useful product is not generated enabling efficient use of non-contaminated material. The above design and operational features would be incorporated in the proposed rare earth processing plant to ensure safe operation and to minimize risk. In addition, the proponent would post chemical safety data sheets at key locations in the small and large factories.

Given the above safeguards and safe handling of the process chemicals, the environmental risks from the chemical process would be very low. The main risk would be from the minor leakage or spillage of chemicals from a vessel or pipeline. In the event that this occurred, the spill would flow across the small or large factories' non-absorbent floors to the drains and sumps for collection and treatment in the waste treatment plants. Excess chemicals would be thoroughly washed off the contaminated floor area into the trade waste collection system.

The process would be essentially carried out at atmospheric pressure except for the reactor vessel which would involve pressure up to two atmospheres. However, the reactor would not be a pressure vessel and would be provided with a vent to prevent explosion and a scrubbing system to clean vented gases. Other emissions from the chemical processes include radon and thoron gases absorbed in wastewaters or diluted in the atmosphere which would have low environmental risks (Sections 6.7 and 6.9). In addition, water vapour and carbon dioxide would be emitted from the process but these would impose no environmental risk.

6.11.3 Agricultural output

The predominant land uses in the area surrounding the site are grazing by cattle with some cropping (mainly soya beans) on prime agricultural land along Leycester Creek floodplain. The cattle would be used for breeding purposes and human consumption and the crops would be used for either animal or human consumption. The agricultural output produced in the vicinity of the proposed rare earth processing plant, and particularly primary food products, would vary according to the area designated, season and mix of agricultural pursuits. In 1984-85 the average agricultural establishment in the City of Lismore was 84 ha and the average production for beef cattle farms was 92 cattle (Department of Agriculture, pers. comm. 1987). Based on these figures and the area of private grazing lands shown in Figure 5.1, approximately 500 beef cattle would have been produced in the vicinity of the site in 1984-85.

The risk that the proposed rare earth processing plant would have any detrimental effect on the agricultural output produced in the vicinity of the proposed plant would be very low. It would be most unlikely that any atmospheric, liquid or solid waste emissions from the proposed plant would affect any agricultural pursuits in the vicinity of the plant. Wastewaters would be contained within existing pipelines and infrastructure for discharge into permanent downstream waterways 5 km from the site. Surface and groundwaters would not be affected by the proposed plant and stock, domestic and general use of local waters could continue unaffected in the vicinity of the proposed plant. The radioactive solid wastes from the proposed plant would all be contained within security fenced and controlled areas so that wandering livestock could not enter the site. As the atmospheric emissions from the plant would contain no particulate matter there would be no contamination of the food chain through fallout on nearby pastures or surface waters. The atmospheric emissions would be significantly below the PDLs designed to protect public health. Overall, the agricultural output, including primary food products, produced in the vicinity of the proposed plant would be highly unlikely to be affected by any emissions or operations of the proposed plant.

6.11.4 Oceanographic and coastal environments

Diluted wastewaters from the proposed rare earth processing plant would be discharged to the South Lismore sewage treatment works for further treatment. Treated effluent from the sewage works is discharged into the headwaters of Hollingsworth Creek for a 97 km journey downstream via the Wilsons and Richmond Rivers to the Pacific Ocean.

The concentrations and loadings of the critical radionuclides in the 320 ML/a of diluted wastewaters discharged from the waste treatment plant to the sewer are shown in Table 6.7 and are based on Section 6.7.2 and Table 2.4.

Table 6.7 Estimated concentrations and loadings of radionuclides in wastewaters discharged

Radionuclide	Concentration (Bq/m ³)	PDL (Bq/m ³)	Annual loading
Lead-210	3.0×10^2	1.0×10^3	< 1 g
Radium-226	2.5×10^1	1.0×10^2	1.1 g
Insoluble natural thorium	3.3×10^3	1.0×10^5	13 kg
Insoluble natural uranium	5.2×10^2	2.0×10^5	0.68 kg

All of the concentrations of the radionuclides in the discharged wastewaters are well under the PDLs specified in the Radioactive Substances Regulations (1959). The PDLs ensure potable drinking water except that discharged wastewaters from the rare earth processing plant would also be contaminated by other physical and biological agents such as sewage, sullage and the loadings shown in Table 2.6.

A qualitative assessment of the potential risks to the oceanographic and coastal environment posed by the discharges described above can be made by an examination of the hydrology of the river systems involved. While only limited data are available, an appropriate analysis may be made by considering only very conservative (worst-case) flow estimates as described below, in terms of the concentration of the radionuclide thorium.

• Stage 1 Rare earth processing plant discharge to South Lismore sewage treatment works

Wastewaters discharged from plant = 1 ML/operating day
= 10^3 m³/d
Concentration of thorium = 3.3×10^3 Bq/m³
Sewage treatment works discharge = 10-15 ML/d average
and 20-25 ML/d during wet conditions
due to rainwater infiltration.
Worst case assumption is 10 ML/d = 10^4 m³/d

If a very low natural abundance of thorium, say 70 Bq/m³ (which is the lower limit of detection), is assumed, then the flow weighted concentration

of $10^3 \text{ m}^3/\text{d}$ of wastewater in $10^4 \text{ m}^3/\text{d}$ of treated sewage effluent would be 360 Bq/m^3 in a total discharge of $11 \times 10^3 \text{ m}^3/\text{d}$.

Stage 2 Sewage treatment works discharge to Hollingsworth Creek flow

Discussions with Lismore City Council have revealed that, though no flow records are kept for Hollingsworth Creek, there are periods during dry weather when the treatment works discharge would constitute a very high percentage of total creek flow.

The conservative assumption is therefore to take Hollingsworth Creek's discharge as $11 \times 10^3 \text{ m}^3/\text{d}$ with a thorium concentration of 360 Bq/m^3 .

Stage 3 Hollingsworth Creek flow to Wilsons River flow downstream of Lismore

Hollingsworth Creek enters Wilsons River just south of Lismore. There are no gauging stations on Wilsons River near this site but after discussions with the gauging authority (the Department of Water Resources) it has been possible to estimate flows at the river confluence.

The most suitable records are for Leycester Creek, at Rock Valley, some 15 km upstream and north-west of Lismore. Leycester Creek is a tributary of Wilsons River whose confluence is at North Lismore; records were obtained for the period October 1951 to December 1985. This 34 year record was analyzed by the Department of Water Resources to derive a flow duration curve which shows the percentage of time that flow equal to or greater than a predetermined value has occurred. In view of the length of record, a high degree of reliability can be placed on this data.

This record can be transposed to the point at which Hollingsworth Creek enters Wilsons River by multiplying daily or monthly flows at the Leycester Creek gauge (Australian Water Resources Council No. 203010) by the ratio of the catchment area at 203010 to the catchment area at the confluence of Hollingsworth Creek and Wilsons River ($179 \text{ km}^2 : 603 \text{ km}^2$).

This is a conservative assumption as it is probable that greater yields (or a higher percentage of rainfall resulting in stream flow) would result in Wilsons River, the catchment of which is partly urbanized, than would be the case in the rural catchment of Leycester Creek.

The flow duration data for 203010 shows the long-term average daily flow to be approximately 50 ML/d (50 percentile) and the very low condition to the 3 ML/d (95 percentile), that is for 95% of the 34 year period of record, flow equal to or greater than 3ML/d was recorded.

Zero flow was recorded at 203010 for 28 days in the 34 years, but this of course would not have resulted in a dry Wilsons River, which is still tidal at Lismore.

A reasonable estimate of flow in Wilsons River at Lismore is therefore:

- average daily flow = 168 ML/d
= $168 \times 10^3 \text{ m}^3/\text{d}$

(obtained from 50 ML/d x 603 km²/179 km²)

- very low flow (95 percentile) = 10 ML/d
= 10×10^3 /d

As before, flow weighted concentration of thorium can be calculated assuming input of $11 \times 10^3 \text{ m}^3/\text{d}$ of water from Hollingsworth Creek at thorium concentrations of 360 Bq/m^3 and very low natural abundance of thorium in Wilsons River. This leads to estimates of:

- 87.4 Bq/m^3 in $179 \times 10^3 \text{ m}^3/\text{d}$ (average flow)
- 220 Bq/m^3 in $21 \times 10^3 \text{ m}^3/\text{d}$ (very low flow).

Stage 4 Wilsons River at Lismore to the Pacific Ocean

As has been shown above, the concentrations of thorium in Wilsons River downstream of the confluence with Hollingsworth Creek would be only about 0.2% of the PDL for that radionuclide and would pose negligible risk to the riverine environment even under very low flow conditions.

It is clearly not possible to say what percentage of the insoluble natural thorium would be deposited at any particular reach of the river, particularly as Wilsons River is subject to tidal influence. However, it can be expected that under varying flow conditions deposition in minute quantities is likely to occur throughout the river system. Hence the likelihood of measurable concentrations of radionuclides reaching the ocean or coastal environments some 97 km away appears to be very remote.

Similar calculations were carried out for the other radionuclides in Table 6.7 with the maximum likely concentrations in Wilsons River expected to be:

lead - 210	20.0 Bq/m^3
radium - 226	1.7 Bq/m^3
insoluble natural uranium	34.7 Bq/m^3

Table 6.8 summarizes the discharge pathways of plant wastewaters and the probable maximum concentrations of radionuclides, which should be compared with the PDLs shown in Table 6.7. The comparison shows that at all times the radionuclides constitute a negligible risk to the receiving waters and that no existing downstream beneficial uses such as irrigation, stock and domestic watering and recreational activity would be adversely affected by the discharge.

Table 6.8 Wastewater discharge pathways

Location	Discharge (ML/d)	Radionuclide concentration (Bq/m^3)			
		Lead-210	Radium-226	Thorium (insoluble natural)	Uranium
Rare earth processing plant	1.0	3×10^2	25	3.3×10^3	5.2×10^2
South Lismore sewage treatment works	11.0	32.7	2.7	3.6×10^2	56.7
Hollingsworth Creek	11.0	32.7	2.7	3.6×10^2	56.7
Wilsons River at Lismore (low flow)	168	20.0	1.7	2.2×10^2	34.7
Richmond River to Pacific Ocean		*	*	*	*

* As most of the above are below detection limits, it seems certain that there would be no measurable radionuclides near the mouth of the Richmond River.

6.11.5 Emergency responses

Emergency procedures to deal with the unlikely events of fire, explosion, release of chemicals and release of radioactive substances would be developed by the proponent in consultation with the appropriate authorities. Public agencies such as local police, fire brigade, ambulance and hospitals would be briefed as to the likely impact and requirements of the proposed rare earth processing plant in the event of an emergency. The emergency procedures would be developed before operation of the plant and would specify who is responsible for co-ordination of activities, what action is to be taken, by whom and in what order. In addition the proponent would conduct employee training programmes so that employees can learn their roles and develop clear communications between the proposed rare earth processing plant and external personnel and services. The proponent would also maintain the existing first aid room and communications systems on site, and make safety equipment available at appropriate locations. Equipment would include radiation monitors and meters, protective clothing, breathing equipment, barriers, blankets, resuscitator and first aid materials.

In the event of a fire or explosion, detailed emergency procedures would be developed between the proponent and Lismore fire brigade before operation of the plant. There are extensive existing fire services on site (Section 5.2.15) with automatic alarms to Lismore fire brigade and additional foam extinguishers would be installed in the large factory.

Some of the emergency procedures for other hazards have already been developed. The Standards Association of Australia has emergency procedure guides for transport of dangerous chemicals in the event of a spill, leak, fire and vehicle accident with appropriate first aid responses as a result of exposure. The Queensland Department of Health has issued emergency procedures in the event of an accident when transporting monazite. These procedures are reproduced below.

Emergency procedures in the event of an accident when carrying radioactive substances as full loads

1. Restrict access to the vehicle and stop movement of traffic through any spilled material.
2. Place safety triangles around vehicle.
3. Notify employer as soon as possible, who will notify the Department of Health immediately.
4. Notify the nearest police station of the accident and the nature of the load.
5. On the direction of the police, or with the approval of the Health Department, remove the vehicle from the accident site, taking appropriate precautions to minimize the further spread of the material.
6. The clean-up of any spilled material will be as directed by the Department of Health.

The above Standards Association of Australia emergency procedure guides and any emergency procedures issued to the proponent by the New South Wales Department of Health would be given to drivers of vehicles transporting chemicals or feedstock. In addition, the New South Wales State Pollution Control Commission has developed a draft chemical response manual that details procedures for the co-ordinated response of government agencies to 'chemical incidents'. This manual details the role of the fire brigade, police and ambulance services and other agencies for emergencies, clean-up and containment procedures and disposal information.

For emergency procedures involving radioactive substances, the proponent would ensure that Lismore Base Hospital, St Vincents Hospital and Lismore ambulance service were in receipt of the NHMRC Notes on medical procedure for radiation accidents and radioactive contamination and the New South Wales Department of Health radiation safety information series No. 3 Procedures to be followed in the handling of radiation accident cases so that appropriate staff could be briefed.

APPENDICES



Department of Environment and Planning



Mr. P. J. Neumann,
Deckhand Pty. Ltd.,
P.O. Box 31,
CURRUMBIN. QLD. 4223

Remington Centre
175 Liverpool Street, Sydney 200
Box 3927 G.P.O. Sydney 2001
DX. 15 Sydney

Telephone: (02) 266 7111 Ext 7230

Contact: G. Douglas

Our reference: 86/2849

Your reference:

7 NOV 1986

Dear Sir,

RARE EARTH SEPARATION FACILITY - LISMORE BREWERY SITE

Thank you for your letter of 20 October, 1986 indicating that you are consulting with the Director with regard to the preparation of an environmental impact statement (EIS) for the above development.

2. As development consent is required for the proposal and it is a designated development within the meaning of Schedule 3 of the Environmental Planning and Assessment Regulation, 1980, as amended, an EIS must accompany the development application to the Lismore City Council. The EIS shall be prepared in accordance with clause 34 of the Regulation and shall bear a certificate required by clause 26(1)(b) of the Regulation (see Attachment No.1).

3. In addition, pursuant to clause 35 of the Regulation, the Director requires that the following matters be specifically addressed in the EIS:

- . an assessment of source and quantities of rare earth materials and the anticipated supply life of the source;
- . a clear indication of the end-use, marketability and efficiency of separation of Thorium oxide as a product (or by-product) of separation is necessary;
- . modes of transportation and selected routes for the transport of raw material and end product/by-product/waste materials and any special procedures in handling these require documentation and assessment;
- . alternative locations considered and the reasons for selection of the site;
- . a detailed assessment of the level of waste water treatment to ensure acceptable chemical and radiation standards for sewer or other disposal means;

- . environmental risk assessment particularly related to the chemical processes involved and potential risks to oceanographic and coastal environment/habitats;
- . alternative chemical processes which may mitigate against environmental risk; and
- . emergency responses to industrial fires and other potential hazards on the site and the types of specific hazards as a consequence of the nature of the materials stored or processed.

4. In preparing your EIS you should approach Lismore City Council and take into account any comments Council considers may apply to its determination of the proposal.

5. Should you require any further information regarding this matter please do not hesitate to contact us again.

Yours faithfully,

A handwritten signature in dark ink, appearing to read 'S. Haddad', written in a cursive style.

S. Haddad

Head, Environment Protection Division
Delegate for the Director

DEPARTMENT OF ENVIRONMENT AND PLANNING
ATTACHMENT No.1

STATUTORY REQUIREMENTS FOR ENVIRONMENTAL IMPACT STATEMENTS.

In accordance with Part IV of the Environmental Planning and Assessment Act, 1979, an environmental impact statement (EIS) must meet the following requirements:

Pursuant to clause 34 of the Environmental Planning and Assessment Regulation, 1980, as amended, the contents of an EIS shall include the following matters:

- (a) full description of the designated development proposed by the development application;
- (b) a statement of the objectives of the proposed designated development;
- (c) a full description of the existing environment likely to be affected by the proposed designated development, if carried out;
- (d) identification and analysis of the likely environmental interactions between the proposed designated development and the environment;
- (e) analysis of the likely environmental impacts or consequences of carrying out the proposed designated development (including implications for use and conservation of energy);
- (f) justification of the proposed designated development in terms of environmental, economic and social considerations,
- (g) measures to be taken in conjunction with the proposed designated development to protect the environment and an assessment of the likely effectiveness of those measures;
- (g1) details of energy requirements of the proposed development and measures to be taken to conserve energy;
- (h) any feasible alternatives to the carrying out of the proposed designated development and reasons for choosing the latter; and
- (i) consequences of not carrying out the proposed development.

The EIS must also take into account any matters required by the Director of Environment and Planning pursuant to clause 35 of the Regulation, which may be included in the attached letter.

The EIS must bear a certificate as required by clause 26(1)(b) of the Regulation.

APPENDIX B LISMORE CITY COUNCIL COMMENTS ON PROPOSAL

The Council of the City of Lismore

*Council Chambers,
Molesworth Street, Lismore, N.S.W.*

TELEPHONES
ADMINISTRATION 21 1501
ENGINEERING 21 1499
PLANNING 21 1497, 21 1523
HEALTH AND BUILDING 21 1479

P O BOX 23A,
LISMORE 2480
DX 7761

ALL COMMUNICATIONS TO
BE ADDRESSED TO
THE TOWN CLERK
PBR:JBG/P2-3

REFERENCE Your Ref: S86060

CONTACT Mr Reynders
FOR FURTHER ENQUIRIES
May 6, 1987

The Manager,
Kinhill Engineers Pty. Ltd.

Dear Sir,

Proposed Rare Earth Processing Plant, Tuncester
Deckhand Pty. Ltd.

I refer to previous discussions between your Mr Adcock and others and Council representatives regarding the preparation of an Environmental Impact Statement for the above proposal.

The requirements under clause 34 of the Regulation, 1980, as supplied by the Department of Environment and Planning and their other requirements have been noted.

This Council requires to receive adequate coverage of those items in the Environmental Impact Statement. The item relating to the risk assessment, particularly related to chemical processes and risks to oceanographic and coastal habitats should cover its risk to agricultural output produced in the vicinity of the plant, if relevant, particularly primary food products.

A development application form, indicating the Council's general requirements, has been provided to you.

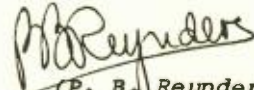
The Council's concern would include impacts from any radioactive materials on public health. The radioactive contamination, shown to be of low specific activity and to meet specified Commonwealth and State Government standards before discharge, should be specified in the Environmental Impact Statement in light of those standards. The discharge method should be described, preferably so the general public can understand the process, (as an Environmental Impact Statement generally is a document for public exhibition).

The Environmental Impact Statement should, where pertinent, use definite terms describing the proposal (will, shall and is, rather than could, should or may be).

Enclosed is some information relating to traffic on adjacent roads, even though this is not up to date.

Regarding the calculation of the development application fee, we believe that, legally, the fee is related to the cost of the development. The development is a processing plant, which without the equipment in the buildings could not be so defined. Therefore, the equipment is a definitive part of the development and, therefore, relevant in calculating the development cost and fee.

Yours faithfully,


(P. B. Reynders)
For the Town Clerk.

enc.

ENVIRONMENTAL PLANNING AND ASSESSMENT ACT, 1979
(SECTION 77 (3))
DEVELOPMENT APPLICATION (not being a subdivision)
The Council of the City of Lismore

OFFICE USE ONLY

File No: _____ / _____
Assessed Fee: _____
Fee Receipt No: _____
Property No: _____

I PETER JAMES NEUMANN of DECKHAND PTY LTD
(Person making application) (Company or Organisation if applicable)
(Business hrs)
Postal Address P.O. BOX 31, CURRUMBIN Phone No 075 347255
hereby apply for development consent to carry out the development described below
on behalf of N/A
(to be completed where applicant is not person or company who will carry out develop-
ment)
POSTAL ADDRESS N/A

A, Description of the land to which the development application relates -
House No. or name _____ Street _____
Locality/suburb _____
Loc, Unit or Portion 1, 2 & 3 Section _____
D.P., S.P. or Parish 178215 CITY OF LISMORE PARISH OF SOUTH LISMORE
Dimensions: Frontage: 222.595m Depth _____ Area 13.47ha Ass. No. .9443/1..&.9444/5..
Owner CARLTON AND UNITED BREWERIES (NSW) of 26 BROADWAY STREET, SYDNEY NSW
~~PTY LIMITED~~

Note: A plan (in triplicate) of the subject land must accompany the application. Refer to Note 2 overleaf.

B, Description of development or other activity (e.g. advertisement, demolition, etc) for which development consent is sought -
RARE EARTH PROCESSING PLANT
Where development involves the erection of a building the proposed use of that building when erected -
N/A

Note: Plans/drawings and other information (in triplicate) describing the development must accompany the application. Refer to Notes 3 & 4 overleaf

C, Estimated cost of the proposed development (where it involves the erection of a building or the carrying out of a work) \$ 1,352,000

Note: Refer to Note 1 overleaf.

D, Environmental Impact of proposed development: _____
The application is accompanied by -
* (a) an environmental impact statement (In the case of designated development)
* ~~(b) a statement of environmental effects~~
* ~~delete whichever is inapplicable~~

Note: Refer to Notes 5 & 6 overleaf

Signature of applicant or person signing on behalf of applicant. Where not signed by applicant, state capacity in which application is signed.

Peter J Neumann
(PETER JAMES NEUMANN)

Date: 18 July 1987

CONSENT OF OWNER

I CARLTON AND UNITED BREWERIES (NSW) PTY LIMITED
of 26 BROADWAY STREET, SYDNEY NSW
being the owner of the land to which this application relates hereby consent to the making of this application.

To be completed where the applicant is not
(a) the owner of the land; or
(b) the lawful occupier of crown land

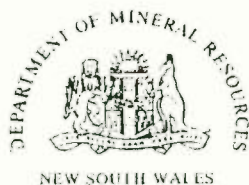
Signature of owner or person acting for or on behalf of owner. Where not signed by owner, state capacity in which consent is signed. Where signed on behalf of the owner(s) proof of authority to sign on their behalf may be required.

Date: 20/7/87

INSTRUCTIONS FOR COMPLETING DEVELOPMENT APPLICATION

1. The fee determined by the consent authority must accompany the application. In the case of a building or work the fee is based upon the estimated cost of that building or work.
2. A plan (in triplicate) of the land to which the application relates must accompany the application indicating the following:
 - (a) the location, boundary dimensions, site area and north point of the land;
 - (b) the existing vegetation and trees on the land;
 - (c) the location and uses of existing buildings on the land;
 - (d) the existing levels of the land in relation to buildings and roads;
 - (e) the location and uses of buildings on sites adjoining the land.
3. A plan or drawing (in triplicate) fully describing the proposed development shall accompany the application and, where applicable, that plan or drawing shall indicate the following:
 - (a) the location of proposed new buildings or works (including extensions or additions to existing buildings or works) in relation to boundaries of the land;
 - (b) floor plans of proposed buildings showing layout, partitioning, intended uses of each part of the building and room sizes;
 - (c) elevations and sections showing proposed external finishes and heights;
 - (d) proposed finished levels of the land in relation to buildings and roads;
 - (e) building perspectives where necessary to illustrate the proposed building;
 - (f) proposed parking arrangements, vehicular ingress, egress and movements on the land (including dimensions where appropriate);
 - (g) proposed landscaping and treatment of the site (indicating plant types and their height of maturity);
 - (h) proposed methods of draining the land.
4. In addition to the material referred to in Notes 2 and 3, the following information shall, where applicable, accompany the development application -
 - (a) In the case of shops or offices or commercial or industrial development -
 - i) details of hours of operation;
 - ii) plant and machinery to be installed;
 - iii) types, size and quantity of goods to be manufactured, stored or transported; and
 - iv) loading and unloading facilities.
 - (b) In the case of demolition - details of the use and condition of the building or works proposed to be demolished.
 - (c) In the case of advertisements - details of the size, type, colour, materials and position of the sign board or structure on which the proposed advertisement is to be displayed; and
 - (d) In the case of development relating to an existing use details of the existing use.
5. An environmental impact statement must accompany the application where the proposed development is designated development.
6. Where the proposed development is not designated development, information -
 - (a) demonstrating that consideration has been given to the environmental impact of the development; and
 - (b) setting out any steps to be taken to mitigate any likely adverse environmental impact,must accompany the application.
7. The consent authority may require additional information of the proposed development to be provided where that information is essential to the determination of the development application.
8. The applicant may support the application with additional material (e.g. photographs, slides, models, etc) which further illustrates the proposed development.

APPENDIX D LETTER FROM DEPARTMENT OF MINERAL RESOURCES



Mr John Latham
Manager
Deckhand Pty Ltd
PO Box 31
CURRUMBIN QLD 4223

Dear Mr Latham

I have been following with keen interest your Company's progress in plans to establish a monazite processing plant to recover rare earth products in New South Wales.

You will be aware that in mid 1986, the Premier requested that the State Development Council, with the assistance of the Department of Mineral Resources, the mining industry and the trade unions, develop a Minerals Processing Plan as part of the New South Wales Government State Development Strategy.

In April 1987, the Premier released a statement on the first stage of the State Development Strategy. Reference was made by the Premier to important minerals processing opportunities identified by the Department of Mineral Resources. It will be of interest to your Company, that processing of rare earths was included in this list of opportunities.

With this in mind and in recognition of the significance to New South Wales of your proposed development in New South Wales, I have instructed officers of my Department to give priority to the project. Further, I have nominated Senior Mineral Economist, Dr Norman Shepherd to act as the Department's contact officer for the project. His functions are to include assisting your company by co-ordinating meetings with other Government Departments.

Yours sincerely


G Rose
Secretary

- 3 JUL 1987



State Pollution Control Commission



Dr. B.W. Thomas,
Director, Deckhand Pty. Ltd.,
Currumbin Minerals Pty. Ltd.,
P.O. Box 31,
CURRUMBIN. QLD 4223

157 Liverpool Street
Sydney 2000
G.P.O. Box 4036
Sydney 2001

Our reference: 708434 PBY:LF

Your reference:

Telephone: (02) 265 8888
Telex Head Office: AA 72234
Fax: (02) 261 2310

Dear Dr. Thomas,

17 JUL 1987

I refer to your letter of 16 June 1987, concerning your Company's proposal to establish a rare earth extraction and processing plant in the Lismore area of northern New South Wales. You have sought advice concerning the Commission's policy on the application of Schedule 3 of the Clean Waters Act in relation to the control of radioactive substances.

This letter will confirm my verbal advice to Mr. Bruce Adcock of Kinhill Stearns, Engineers, your consultants on this proposal.

In New South Wales the transport, use, storage and disposal of any radioactive substance is controlled and regulated by the provisions of the Radioactive Substances Act, 1957 (as amended) and by the Radioactive Substances Regulations, 1959 (as amended). The Act and Regulations are administered by the Radiation Control Branch of the Department of Health.

Provided that, in relation to radioactive substances or wastes, your proposal accords with the requirements of the Department of Health, in its administration of the Radioactive Substances Act and Regulations, you will not be required to satisfy additional requirements of the State Pollution Control Commission under the Clean Waters Act. Schedule 3 to that Act will not be applied, unless called up by the Department of Health.

You should appreciate that, notwithstanding the above comments on radioactive substances, your proposal may well require a pollution control approval or licence from the Commission under the provisions of the State Pollution Control Commission Act and the State's other pollution control legislation. If you are unsure of the requirements of the legislation I suggest you make further inquiries.

If you have any inquiries concerning the matters referred to above, please do not hesitate to telephone me on (02) 265-8864. Inquiries concerning the requirements of the Department of Health on radioactive substances should be directed to Mr. Arnold Fleischmann, Officer-in-Charge, Radiation Control Branch on (02) 545-0327.

Yours faithfully,



P.B. YATES
Chief - Chemicals and Noise Division,
for Secretary

17 JUL 1957

ccs . Mr.B. Adcock, Kinhill Stearns, Engineers.
. Mr. A. Fleischmann, Department of Health.

. [5W-LF, CCND1, L-PNBV5] .

APPENDIX F

GLOSSARY

Activity	The number of disintegrations per unit time taking place in a radioactive material.
Alpha particle	A positively charged particle containing two protons and two neutrons which is emitted by certain radioactive material.
Becquerel	The unit of measurement of radioactive decay defined as one radioactive disintegration per second. The disintegration may occur as a result of emission of an alpha particle or a beta particle.
Beta particle	A positively or negatively (more usual) charged particle emitted from a nucleus during radioactive decay.
Bund	An earth rock or concrete wall constructed to prevent the inflow or outflow of liquids.
Calcine	The residue derived from heating a mineral substance with air to drive off the chemically combined volatile portion of the substance and to convert the non-volatile mineral to an oxide.
Chelating agent	An organic compound in which atoms form more than one co-ordinate bonds with metals in solution.
Controlled area	An area to which access is subject to control in order to limit the radiation exposure of employees.
Daughter products	Radionuclides which are formed as a result of radioactive decay of a specified radionuclide.
Decay product	The product of the spontaneous radioactive decay of a nuclide. A substance such as Uranium 238 decays through a sequence of steps and has associated with it many successive decay products in a series.
Designated employee	An employee who works under conditions such that his annual employee dose equivalent might exceed 5mSv. Other employees are non designated employees.
Dose	The radiation energy absorbed in a unit mass of material.

Dose-equivalent	The mathematical product of the absorbed dose, the quality factor and any other specified modifying factors. The quality factor accounts for the effectiveness of energy transfer of the ionizing radiation in producing a biological detriment. Modifying factors are those which may act to modify the effect of the energy imparted to the matter.
Gamma radiation	A form of electromagnetic radiation similar to light or X-rays, distinguished by its high energy and penetrating power.
Groundwater	Underground water contained within a saturated zone or rock usually as an aquifer.
Half-life	The time taken for the activity of a radioactive isotope to decay to half of its original value, that is for half of the atoms present to disintegrate. Half-lives vary from isotope to isotope, some being less than a millionth of a second and some more than a million years.
Ionizing radiation	Radiation which interacts with matter to remove electrons from the atoms of the materials absorbing it, producing electrically charged atoms called ions.
Isotope	One of two or more forms of an atomic element having the same number of protons but a different number of neutrons. All isotopes of the same element have the same chemical properties and therefore cannot be separated by chemical means.
Public derived limit	Radiation limits for members of the public based on ICRP and limit NHMRC publications.
Radioactive	Spontaneously emitting radiation by nuclear transformation.
Radionuclide	A nuclide of an atom that is radioactive.
Radon	The radioactive gases Radon-222 and Radon-220 (commonly called thoron). The predominant isotope Radon-222 has a half-life of 3.8 days.
Radon daughters	A term applied to the short-lived decay products of radon gas. For Radon-222 the relevant daughters are Polonium-218, Lead-214, Bismuth-214 and Polonium-214. For Radon-220 the relevant daughters are Lead-212, Bismuth-212 and Polonium-212. See Figure 3.1.

Rare earths	A group of metals with atomic numbers from Lanthanum (atomic number 57) to Lutetium (71). Yttrium (39) and Scandium (219) while not strictly rare earths are sometimes grouped with them. They have very similar chemical and physical properties making separation of individual elements difficult.
Secular equilibrium	A condition which occurs when the activity of the decay products is equal to that of the parent in a material. It may arise when a radioactive parent is long-lived compared with its decay products and none of the decay products are removed from the material.
Sievert	The unit of measurement of radiation dose-equivalent. One sievert is equal to the product of the absorbed dose by the quality factor and any modifying factor(s). It allows a comparison of the relatively greater biological damage caused by some particles such as alpha particles and fast neutrons. For most beta and gamma radiation, one sievert is equal to an absorbed dose of one joule per kilogram.
Solvent extraction	A separation process in which two immiscible solvents (water-based and organic-based) are brought into contact for the transfer of chemical components.
Supervised area	An area to which access is controlled in order to limit the radiation exposure to members of the public.
Thorium (decay) series	A series of radionuclides produced in the decay of radioactive thorium to stable lead. See Figure 3.1.
Uranium (decay) series	A series of radionuclides produced in the decay of radioactive uranium to stable non radioactive lead. See Figure 3.1.
Working level	The quantity of radon decay products (radon daughters) in one litre of air which will result in the emission of 130,000 million electron volts of alpha particle energy. If the radon daughters are in equilibrium with radon in the air, then 3.7 becquerels of radon per litre of air is equivalent to one working level.
Working level month	A measure of the total radiation dose which would be received by someone breathing air containing radon daughters at a concentration of 1 working level throughout the working period of a month (168 hours).

APPENDIX G

ABBREVIATIONS

Measurements

Technical units of measurement in this report are based on the International System of Units (SI) wherever possible. These technical units may be broadly grouped as prefixes and measurements. Different units are combined by a full stop(.) to differentiate units of the same exponential sign, and a solidus (/) to indicate 'per'. For example, kilometres per hour is abbreviated as km/h, while megalitres per day per kilometre² is ML/d.km².

The prefixes used in this report are:

M	mega	1,000,000
k	kilo	1,000
m	milli	0.001
μ	micro	0.000001

Units of measurement that have been used are:

a	annum	m	metre
Bq	becquerel	m ²	square metres
°C	degree Celsius	m ³	cubic metres
d	day	ppm	parts per million
g	gram	pH	measure of acidity
h	hour	Sv	sievert
ha	hectare	t	tonne
kW.h	kilowatt hour	V	volt
L	litre	%	per centage

Miscellaneous

ALARA	As Low As Reasonably Achievable
EIS	Environmental Impact Statement
ICRP	International Commission on Radiological Protection
NHMRC	National Health and Medical Research Council
PDL	Public Derived Limit
WL	Working Level
WLM	Working Level Month

APPENDIX H

REFERENCES

- Anstett, T.F. 1986. Availability of rare-earth, yttrium and related thorium oxides -market economy countries. A minerals availability appraisal. Information circular 9111. Washington: United States Department of the Interior.
- Australian Atomic Energy Commission. 1984. Demonstration of an initial screening phase for site selection for low level radioactive waste burial - an evaluation of relevant IAEA guidelines. Sydney: Australian Atomic Energy Commission.
- Australian Environment Council. 1986. National guidelines for the management of hazardous wastes.
- Australian Heritage Commission. 1981. The heritage of Australia. Melbourne: Macmillan.
- Bureau of Meteorology. 1972. Climatic survey, Richmond-Tweed, Region 1 New South Wales. Canberra: AGPS.
- Bureau of Mineral Resources. 1987. Australian Mineral Industry annual review for 1984. Canberra: AGPS.
- Bureau of Mineral Resources, Geology & Geophysics and Australian Bureau of Statistics. 1986. Australian Mineral Industry quarterly. Canberra: AGPS.
- Bureau of Resource Economics. 1987. Processing of Australia's mineral exports: An overview. Canberra: AGPS.
- Central Mapping Authority of New South Wales. 1986. Topographic maps 1:25,000: Casino and Lismore.
- Chesnut, W., and I. Swane. 1980. Geological factors influencing urban development in the Lismore region. Geological survey of NSW. Department of Mineral Resources. Report No. GS1976/349.
- Commonwealth of Australia. 1980. Code of practice on radiation protection in the mining and milling of radioactive ores. Canberra: AGPS (under revision).
- 1981. Recommended radiation protection standards for individuals exposed to ionising radiation. Canberra: AGPS.
- 1982. Code of practice on the management of radioactive wastes from the mining and milling of radioactive ores. Canberra: AGPS.
- 1982. Code of practice for the safe transport of radioactive substances. Canberra: AGPS (under revision).
- 1984. Australian code for the transport of dangerous goods by road and rail. In Commonwealth Gazette (9 April 1984).

- 1986. (Unpublished draft.) Implementation of dust control strategies in the mineral sands industry.
- Commonwealth - State Consultative Committee. 1985. The management of radioactive wastes arising from the medical, industrial and research use of radionuclides.
- Cooper, P.F., A.A. MacNevin, and K. Winward. 1979. The mineral industry of New South Wales. No's. 40, 44 and 38. Titanium Zirconium Thorium: Geological Survey of New South Wales. Department of Mineral Resources and Development.
- Department of Environment and Planning. 1987. North Coast draft regional environmental plan. Sydney: Department of Environment and Planning.
- Department of Mineral Resources. 1983. Minfo 3.
- 1984. Minfo 5.
- 1985a. Non-traditional minerals of NSW.
- 1985b. Minfo 8, 9, 10.
- 1986a. Minfo 12.
- 1986b. Minfo 13.
- 1986c. Minerals and metals of NSW.
- Department of Science. 1986. Rare earths report on a visit by an Australian delegation to the People's Republic of China. Canberra: Department of Science.
- Drury, L.W. 1982. Richmond River valley groundwater investigation. Water Resources Commission. Hydrogeology Report No. 1982-13.
- Evans, G. 1987. Press Statement. 15 January 1987. Canberra.
- Gentilli, J. 1972. Australian climate patterns. Melbourne: Thomas Nelson.
- Griffiths, J. 1984. Rare earths - attracting increasing attention. Industrial Minerals (April).
- Health Commission of New South Wales (n.d.). Procedures to be followed in the handling of radiation accident cases. Radiation safety information series. No. 3.
- International Atomic Energy Agency. 1981. Shallow ground disposal of radioactive wastes - a guidebook. Safety series No. 53. Vienna: International Atomic Energy Agency.
- Kinhill Stearns. 1985. Proposed rare earth processing plant. Environmental review and management programme, draft environmental impact statement Vol. I, Technical appendices Vol. II and supplement, incorporating the work of B. O'Connor and R. Chang (1985). Perth: Kinhill Stearns.
- Lismore City Council. 1986. Lismore draft local environmental plan 1986. Lismore: Lismore City Council.

- National Health and Medical Research Council. 1969. Notes on medical procedure for radiation accidents and radioactive contamination.
- 1982. Occupational health guide. Recognition and appraisal of chemical hazards. Commonwealth Department of Health.
- 1986. Code of practice for the disposal of radioactive wastes by the user (1985). Canberra: AGPS.
- Nicholls, K.D., and B.M. Tucker. 1956. Pedology and chemistry of the basaltic soils of the Lismore district, NSW. CSIRO Soil Bulletin No. 7.
- Resource Information Unit. 1986. Register of Australian mining, 1985-1986. Perth.
- Slatyer, R.O. (Chairman, Australian Science and Technology Council). 1984. Australia's role in the nuclear fuel cycle. Canberra: AGPS.
- Soil Conservation Service of NSW. 1982. Land capability series, Lismore map.
- Standards Association of Australia. Transport of hazardous materials AS 1678. Emergency procedure guides. Sydney: Standards Association of Australia.
- 1979. The design of earthquake-resistant buildings known as the SAA earthquake code. Sydney: Standards Association of Australia.
- 1981. Classification, hazard identification and information systems for dangerous goods AS 1216, part 1 - classification and class labels for dangerous goods. Sydney: Standards Association of Australia.
- 1984. AS 1055 Acoustics - description and measurement of environmental noise. Sydney: Standards Association of Australia.
- State Pollution Control Commission. 1986. (unpublished draft). Chemical response manual.
- United States Department of the Interior. 1985. Rare earth elements and yttrium. In Mineral facts and problems. Bulletin 675. Washington: United States Department of the Interior.

LEGISLATION

Commonwealth

Environment Protection (Nuclear Codes) Act 1978

Nuclear Non-Proliferation (Safeguards) Act 1987

New South Wales

Environmental Planning and Assessment Act, 1979 and Regulations

Radioactive Substances Act, 1957 and Regulations

Clean Air Act, 1961 and Regulations

Clean Waters Act, 1970 and Regulations

Noise Control Act, 1975 and Regulations

State Pollution Control Commission Act 1970, and Regulations

Dangerous Goods Act, 1975 and Regulations

Occupational Health and Safety Act, 1983

Factories, Shops and Industries Act, 1962 and Regulations

Local Government Act, 1919

APPENDIX I

STUDY TEAM

This Development Application and Environmental Impact Statement were prepared for Deckhand Pty Ltd by the study team listed below.

Kinhill Engineers Pty Ltd

B.R. Adcock	Project Manager
R.P. McLoughlin	Waste Repository Design
S.M. Harper	Chemicals Storage Design
V. Farrington	Atmospheric Emissions
Dr. R.E. Black	Hydrological Aspects
Dr B.R. Jenkins	Technical Review
E.M. Hill	Editing Review
M. Szabo	Graphics
B. Chan	Word Processing
D.J. Taylor	Word Processing

Subconsultants to Kinhill Engineers Pty Ltd

Dr B. O'Connor	Curtin University of Technology for Radiation Aspects
Australian Nuclear Science and Technology Organisation	Radiation Analyses

DECKHAND PTY LTD

EIS
378

Rare earth processing plant at
Tuncester

