## executive summary

### 1.0 introduction

1.1 Background and Site Overview 12  
1.2 Purpose of the Long Term Residue Management Strategy 12  
1.3 Structure of Report 13

### 2.0 background and history of the LTRMS

2.1 Initial LTRMS Development 15  
2.2 2000 LTRMS Review 16  
2.3 2005 LTRMS Review 17  
2.4 2012 LTRMS Review 17  
2.5 Sustainability 17  
2.6 Alcoa’s Stakeholder Engagement Process 18  
2.7 Wagerup LTRMS Stakeholder Consultation Process 18

### 3.0 alumina refining process

3.1 Overview 22  
3.2 Digestion 22  
3.3 Clarification 22  
3.4 Precipitation 22  
3.5 Calcination 22  
3.6 Power and Steam Generation 22  
3.7 Residue and Waste 22  
3.8 Refinery Water Circuit 23

### 4.0 bauxite residue management

4.1 Overview 24  
4.2 Residue Characteristics 24  
4.3 Physical Structure of Storage Areas 26  
4.4 Footprint Design 26  
4.5 Construction of New Residue Facilities 27  
4.6 Bauxite Residue Research and Development Activities 27

### 5.0 economic and social setting

5.1 Description of the Local Community 31  
5.2 Social Assessment Review 31  
5.3 Overview of Alcoa’s Economic and Social Contribution 32
## 6.0 Environmental, Heritage and Planning Setting

6.1 Climate 34
6.2 Topography 34
6.3 Hydrology 35
6.4 Flora and Fauna 36
6.5 Heritage Sites 37
6.6 Existing Land Use and Tenure 38
6.7 Local, Regional and State Planning Policies and Visions 40

## 7.0 Existing Environmental Issues and Management Strategies

7.1 Environmental Management Systems 42
7.2 Dust Alcoa’s Commitments 42
7.3 Odour & VOCs 46
7.4 Radiation 47
7.5 Residue Emissions and Health 48
7.6 Waste 50
7.7 Water Use 51
7.8 Surface Water 52
7.9 Groundwater Impacts 53
7.10 Land Use Management and Visual Amenity 55
7.11 Residue Area Rehabilitation 57

## 8.0 Future Residue Development Strategies

8.1 Residue Planning and Design Framework 60
8.2 Constraints on Forward Planning of Residue Operations 60
8.3 Future Residue Planning 61
8.4 Residue Area Planning Considerations 62
8.5 Life-of-Mine Strategy (2045) 65
8.6 Mid-Term Strategy (25 years) 65
8.7 Short-Term Construction Strategy (5-7 years) 66
8.8 Planning Strategy to Support Future Residue Development Requirements 68

## 9.0 Residue Closure and Rehabilitation

9.1 Closure Strategy Options 70
9.2 Current Closure Strategy 71
9.3 Water Balance/Discharge Management 72
9.4 Future Land Use Options & Revegetation 72
9.5 Closure Funding 73
9.6 Closure Guiding Principles and Alcoa’s Commitments 73

## 10 Stakeholder Reference Group Guiding Principles

10.1 Summary of Guiding Principles and Alcoa’s Response 75

## 11 Glossary

11.1 Document History and Status 82
11.2 Distribution of Copies 82

## 12 References

12.1 84
Introduction
The Wagerup Long Term Residue Management Strategy (LTRMS) was initially developed to meet Ministerial Conditions associated with the Wagerup Unit Two expansion. Alcoa committed to develop long-term and closure management plans for bauxite residue deposits. In order to keep the plan current it is reviewed and updated on a five yearly basis. This LTRMS represents the fourth published strategy for Alcoa’s Wagerup Alumina Refinery.

A reference group of key stakeholders including community members, local and state government and Alcoa representatives, actively participated in the development of the strategy over a three month period. The majority of the document’s content reflects presentations to and outcomes from, the Stakeholder Reference Group process, with additional contextual information provided as required.

The LTRMS is a reflection of current knowledge, technology and regulatory standards. The document does not provide detailed engineering information for future residue management; however such information is available from Alcoa upon request.

Purpose of LTRMS
The LTRMS document is designed to inform local and state governments and the wider community of Alcoa’s long-term management strategies and commitments for a sustainable future in bauxite residue management. In particular it outlines the current short-term (5-7 year), mid-term (25 year) and life-of-mine (2045) management strategies for Wagerup Refinery bauxite residue, including issues such as:

- where future residue infrastructure areas will be located,
- the proposed height requirements for the residue drying areas, and
- how environmental risks associated with residue storage will be managed.

The LTRMS also addresses current plans for closure of the bauxite residue area, future land use options for the residue area after closure and current research into residue management, re-use and revegetation. It is not intended to duplicate documents or processes already in place to address current operational management issues. These issues are managed via the Environmental Management System (EMS) and Environmental Improvement Plan (EIP) processes for the Wagerup Refinery.

This report is designed to enable stakeholders to review both the longer-term strategy and those projects on the immediate planning horizon. The LTRMS is anticipated to address the key information requirements of the planning and approval mechanisms for the 5-7 year period to which it relates so that endorsement of this document by the Residue Planning Liaison Group (RPLG) and Ministers for State Development and Environment ensures streamlined approvals processes. Similarly, endorsement of the 25 year and life-of-mine planning footprints is designed to provide a basis for rezoning applications required for the longer term residue infrastructure.

The outcomes of this LTRMS will also be incorporated into the ongoing planning processes for the Wagerup residue area, including the development of annual, 5 year and 25 year facilities plans.
Consultation and Key Issues

The contents of this document are based on issues and information discussed during consultation with a Stakeholder Reference Group formed from members of the community, local and state government departments and Alcoa. The purpose of consulting broadly with the community and government stakeholders in the development of the updated LTRMS was to:

• have stakeholders directly involved in the planning process,
• ensure that the concerns and queries of the local community, local governments and regulatory authorities are considered, and
• ensure Alcoa’s responses to these issues are transparent and documented.

A summary of the Stakeholder Reference Group’s deliberations has been provided in the form of 29 Guiding Principles to Alcoa for consideration in the development of the LTRMS. These were developed on environmental and social issues considered particularly significant by the working group, and include:

• residue reuse,
• dust control and management,
• odour and volatile organic compound (VOC) emissions,
• residue emissions and health,
• oxalate management,
• water use,
• groundwater,
• visual amenity,
• residue rehabilitation,
• alternative residue storage techniques,
• separation distance and height, and
• residue closure.

These Guiding Principles, together with Alcoa’s response is documented in Section 10. Details of the current and future management strategies proposed to address these issues are contained within the body of the report.

Residue Footprint Options

The ultimate land area under residue storage will be affected by the volume of residue requiring storage, the rate at which residue is produced and at which it can be dried (and hence the open drying area required at any time), and the way the residue stack is constructed.

The most significant factor affecting the final volume of residue requiring storage is the availability of alternative uses for residue. The other significant factor affecting the final footprint of the residue area is the stack design. Specifically the height to which the stack can be created, while providing the required open area for drying, determines the minimum residue footprint that can be achieved.

Alcoa believes that many sustainability aspects of its residue operations (social, environmental and financial) are improved by seeking to minimise the final footprint of the residue area.

The following social and environmental aspects of minimising the final footprint have potential, if not properly managed, to be negatively impacted:

• visual amenity of a higher residue stack, and
• dust emissions associated with higher wind speeds at increased stack heights.

A minimised footprint is being sought by research and commercialisation efforts into alternative reuse options, as well as opportunities to reduce the active drying area requirements for residue mud. In addition, the design of the residue stack is optimised wherever possible to ensure the most efficient use of land.

Alcoa is in the process of updating the comprehensive management plan for the medium term (25 years) and finalising the five year Residue Management Plan for 2012-2017. These plans are developed using the guidance provided through the Long Term Residue Management Strategy Stakeholder Reference Group process.

Constraints on Forward Planning

Despite the level of effort which goes into forward planning, significant shifts in direction are occasionally required as a result of a range of factors, including:

• changes in technology;
• changes at the refinery affecting the rate of production;
• changes in quality of bauxite and/or characteristics of residue material streams (the drying area required can be affected by small changes in the percentage of mud in the residue, with higher percentages of mud requiring a greater drying area);
• weather conditions, in so far as they can affect mud drying rates and the construction schedules of new residue areas;
• input from the community and regulatory agencies in the process of obtaining the necessary statutory approvals for new residue areas;
• internal funding availability, which is influenced by a number of factors including the global aluminium market; and
• availability of key equipment and contractors.

Alcoa believes that many sustainability aspects of its residue operations (social, environmental and financial) are improved by seeking to minimise the final footprint of the residue area.
The plans presented in the LTRMS are therefore subject to change. The five yearly review process for the LTRMS is designed to allow these changes and their impact on long-term planning for the residue area to be reviewed with community and government stakeholders. In the event that a significant change will impact the 5-7 year plan presented in this document, additional consultation may be required.

Within the next 25 years, assuming current production rates, up to 250 hectares of additional drying area is required. Projects designed to provide approximately 80 hectares of the required drying area are currently planned to be constructed between 2012 and 2019.

**Short-Term Construction Strategy**

Key issues to be managed within the five year time frame are:

- maintaining the residue storage and drying capacity to meet the requirements of the refinery, and
- maintaining the water storage, surge capacity, cooling and process water supply functions for the refinery, ensuring they can service the increased drying areas.

Over the period 2012-2019 Alcoa currently plans to provide new drying areas for current production rates through construction of two greenfield drying areas, RSA 9 and RSA 10, a new Run Off Collection Pond (ROCP) and new Run Off Water Storage (ROWS) Pond, within the current industrial zoned area. The new drying areas will provide approximately 80 hectares of additional drying area. Construction of RSA 9 and the new ROCP is currently underway. The location of these new areas is shown in Figure ES-1.

**Mid-Term Construction Strategy**

Alcoa’s focus for the mid-term strategy is to consolidate the existing residue area to make more efficient use of the drying area, improve dust management and reduce risk of groundwater contamination. The mid-term residue construction activities planned to achieve this include:

- construction of new residue areas RSA 9-14;
- construction of new Run Off Collection Pond (ROCP4); and

![Figure ES-1: Current 25 year residue footprint.](image-url)
• relocation of infrastructure, as required, to support the above projects.

The location of these new areas is shown in Figure ES-1.

Life-of-Mine Strategy
Alcoa has developed an indicative life-of-mine strategy for the residue area. For purposes of this planning process, the life-of-mine is considered the life of Alcoa’s current bauxite mining lease, Mineral Lease 1SA (2045). The life-of-mine strategy assumes that the proposed Wagerup 3 expansion is implemented, the residue stacks are developed to a height of 60 metres above natural ground level (74 metres RL) and that the footprint is expanded in a westerly then northerly direction.

Closure Strategy
The process of defining the closure strategy will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes at the time may have changed. The current closure strategy has three main objectives; that decommissioned residue areas should have the capability to be used for productive community benefit, be safe and self-sustaining in the long-term, and allow future access to bauxite residue for alternate uses. Key considerations at closure relate to the final form of the residue area, management of contaminated stormwater, management of leachate and final land use. The current closure strategy aims to rehabilitate the deposit to allow it to be used for a range of activities for future generations.

Ongoing Stakeholder and Community Engagement and Review Schedule
The LTRMS will be periodically reviewed. The frequency of these reviews is determined in conjunction with the Residue Planning Liaison Group and is currently five yearly. The process of future stakeholder consultation is anticipated to be similar to that undertaken in this review.

Concluding Remarks
The development of this LTRMS has been a constructive means of engaging the community. Alcoa is very appreciative of the Wagerup LTRMS Stakeholder Reference Group members who have provided a considerable amount of personal time and commitment in working with Alcoa during 2012 to produce this LTRMS for the Wagerup Refinery.
introduction

The Wagerup Long Term Residue Management Strategy (LTRMS) was initially developed to meet Ministerial Conditions associated with the Wagerup Unit Two expansion. Alcoa committed to develop long-term and closure management plans for bauxite residue deposits. In order to keep the plan current it is reviewed and updated on a five yearly basis. This LTRMS represents the fourth published strategy for Alcoa’s Wagerup Alumina Refinery.

1.1 Background and Site Overview

In Western Australia, Alcoa owns and operates alumina refineries at Kwinana, Pinjarra and Wagerup, with a combined capacity of approximately nine million tonnes per annum (mtpa), equivalent to around 45% of Australian production and more than 10% of world demand. The company also operates bauxite mines at Huntly and Willowdale in the Darling Range, south of Perth. A map of Alcoa’s operations in Western Australia is provided in Figure 1-1.

Alcoa’s Wagerup Alumina Refinery is situated 120 kilometres south of Perth, 2.5 kilometres north of Yarloop and approximately 7 kilometres south of Waroona. The refinery is positioned close to the foot of the Darling Scarp and is separated from the Wagerup Refinery residue area by the South West Highway and the Perth-Bunbury railway line. The land surrounding the Wagerup Refinery and residue area is predominantly operated as a beef farming enterprise by Alcoa’s Farmlands operations.

The Wagerup Refinery commenced operations in 1984 producing 700,000 tonnes of alumina per year. Production capacity was increased to 1,750,000 tonnes of alumina per year in 1990 and further expanded to 3.3 million tonnes per annum in 1995. The proposed Unit Three Expansion has been approved by the Environmental Protection Authority (EPA) and State Government and has the potential to lift capacity to 4.7 million tonnes per annum. Although approval has been given for Alcoa to expand the Wagerup Refinery, the expansion plans are currently on hold due to the challenging economic environment and the need to secure energy supplies. Alcoa considers its Wagerup Refinery to be technically the most environmentally advanced alumina refinery in the world.

Bauxite is supplied to the refinery by overland conveyor from Alcoa’s Willowdale bauxite mine located 15 kilometres to the east. Alumina produced at Wagerup Refinery is transported by rail to Alcoa’s Bunbury shipping terminal and then exported to overseas markets or to Alcoa’s aluminium smelters in Victoria. The bauxite is low grade by world standards, requiring three tonnes of bauxite to produce one tonne of alumina. As a result, large volumes of bauxite residue are generated and stored in bauxite residue drying areas west of the refinery.

1.2 Purpose of the Long Term Residue Management Strategy

This Long Term Residue Management Strategy (LTRMS) document is designed to inform both the local and state government and the community of Wagerup Refinery’s long term residue management strategy and associated commitments. The contents of this document provide information on the issues requiring consideration in the management of bauxite residue and Alcoa’s strategies in relation to future residue facilities.
A reference group of key stakeholders including community members, local and state government and Alcoa representatives actively participated in the development of the strategy during a three month period. The majority of the document’s content reflects presentations to, and outcomes from, the Stakeholder Reference Group (SRG), with additional contextual information provided as required.

The LTRMS is a reflection of current knowledge, technology and regulatory standards. The document does not provide detailed engineering information for future residue management; however such information is available from Alcoa upon request.

1.3 Structure of Report
The contents of the key sections of this report are outlined below:

Section 2: Background and history to the development of the LTRMS and the evolution of the stakeholder engagement process to support its development.

Section 3: Overview of Wagerup Refinery’s operations and the alumina refining process.

Section 4: Bauxite residue characteristics, design and construction of storage areas, and current residue research and development activities.

Section 5: Social and economic setting in which the Wagerup Refinery operates.

Section 6: Environmental, heritage and planning setting of the Wagerup site.

Section 7: Environmental management strategies for residue storage, changes in management since the last LTRMS review, impacts and management of an expanded footprint.

Section 8: Short, medium and life-of-mine residue development strategies, focusing on major infrastructure requirements and projects for each period.

Section 9: Closure strategy and future land use options.

Section 10: Guiding principles for residue management as developed through the 2012 Wagerup LTRMS Stakeholder Reference Group process.

Section 11: Glossary of terms, units and terms.

Section 12: References.
Alcoa has had an active residue management program for the past 46 years that has focused on emissions control, improvement in engineering management practices and alternative uses for residue.

2.1 Initial LTRMS Development
As part of the 1989 Consultative Environmental Review (CER) for the Wagerup Unit Two Expansion, Alcoa agreed to develop long-term and closure management plans for residue deposits in consultation with relevant State agencies, as well as to submit design reports and monitoring results from the Residue Storage Areas (RSAs) to the then Water Authority of Western Australia (WAWA). In March 1990 the Minister for the Environment authorised the proposed expansion, subject to certain conditions including the development of a satisfactory “walk away solution” for the residue deposits.

In response to these conditions the Residue Planning Liaison Group (RPLG) was formed in 1992. The role of the RPLG was to facilitate the planning activity and to review and endorse the plans developed by Alcoa for submission to the Minister for State Development and the Minister for the Environment. The RPLG initially had membership from the Department of Resources Development (chair), Department of Environmental Protection, Water and Rivers Commission, Department of Minerals and Energy, Ministry of Planning, Agriculture Western Australia, The Peel Development Commission, Department of Conservation and Land Management, and Alcoa.

The RPLG agreed to the following main elements of the LTRMS:

- identification of the major stakeholders in the planning process and a listing of the key issues of concern to them;
- discussion of the key issues, the environmental concerns stemming from them, and the current and recommended future management strategies to address them;
- conceptual plans for the expansion of drying facilities over the 50 year planning period;
- recommendation of a closure strategy for the deposits which satisfies, as far as possible, the concerns of the major stakeholders; and
- analysis of the gaps between the current situation and the desirable end condition and thereby identify improvement opportunities and research and development needs.

In addition, the RPLG agreed on a process and schedule (five yearly) for review of the LTRMS. Alcoa voluntarily agreed to extend this process to the Pinjarra and Kwinana Refineries.

During the development of the draft LTRMS for Wagerup, Alcoa submitted another Consultative Environmental Review (CER) for a further expansion of the refinery’s production capacity to 3.3 million tonnes per annum. This CER reinforced Alcoa’s existing commitments to residue management with minor rephrasing of existing conditions to take into account the processes put in place since approval of the 1989 CER, such as the formation of the RPLG. The Minister for the Environment authorised the expansion in August 1995. The Minister’s statement (Number 390) replaced the earlier 1989 Ministerial conditions with...
expanded and clarified conditions related to long-term residue management. These required Alcoa to:

- develop a closure strategy and long-term management plan for the residue storage areas at Wagerup in consultation with the RPLG, to the satisfaction of the Minister for Environment;
- report annually on progress towards developing the closure strategy;
- implement the closure strategy to the satisfaction of the Minister for Environment (the timing of implementation shall be determined on advice from the Minister responsible for administering the Alumina Agreement Act); and
- periodically review the long-term management plans for the residue deposit in consultation with the RPLG.

The Wagerup Refinery LTRMS was developed in 1995 as a single document to meet the requirements of both the long-term management plan and closure strategy for the residue area. In order to complete the closure strategy, a detailed study was undertaken of the residue drying facility requirements to sustain 50 years of alumina production at the Refinery. The primary focus of the original Wagerup LTRMS (Alcoa, 1997) was on detailing the engineering elements of residue planning and closure, demonstrating sound environmental management of residue and compliance with legal and corporate requirements. A series of key technical recommendations arose through the development of the 1995 LTRMS.

The LTRMS was submitted to the RPLG in February 1996. The Minister for the Environment signed off in February 1997 that the Ministerial Condition on the closure strategy had been met.

2.2 2000 LTRMS Review
Alcoa initiated a review of the 1995 LTRMS in early 2000 as part of the commitment to the RPLG for five yearly reviews. During the review period Wagerup Refinery came under increased public focus and Alcoa recognised the need for improved community and local government involvement on bauxite residue planning. A protracted consultation process followed, which resulted in a much improved strategy with greater awareness and participation by stakeholders in Alcoa’s residue.
planning programs. However it also caused the delays in its release, with the final report being endorsed by the RPLG in December 2003.

The following key changes to the LTRMS review process and content were endorsed by the RPLG as a result of the 2000 review:

- the Waroona Shire Council is now represented on the RPLG in recognition of the need to improve the linkage between the Council’s planning approval process for individual RSAs and the LTRMS,
- the strategy’s planning horizon was recommended to be reduced to 25 years, and
- the LTRMS was proposed to include more detailed facilities planning information for the 5 year review period to which it relates, to allow projects on the immediate planning horizon to be reviewed as part of the long-term strategy. This structure also aims to reduce duplication in the approvals processes by providing information necessary to support the planning and approval mechanisms for the 5 year period.

2.3 2005 LTRMS Review

Alcoa announced its intention to seek environmental approval to increase production capacity to 4.7 million tonnes per annum in 2004. A number of community working groups were established to consult on environmental and social issues associated with the expansion. A Water and Residue Working Group was consulted on the impacts resulting from expanded residue storage requirements. This group submitted a report containing their recommendations to Alcoa which was incorporated into the Environmental Review and Management Programme (ERMP).

The ERMP for the expansion, which was submitted to the EPA in May 2005, acknowledged the availability of the LTRMS review process to consult on the broader issues of residue management outside of the scope of the ERMP, such as possible alternative uses for residue. In addition, it recommended the LTRMS review process be used to consult specifically on the long-term stack height and footprint options for the expanded refinery. The increased residue storage requirements were also acknowledged in the ERMP.

This review of the LTRMS commenced in September 2005 and addressed the ERMP proposal to consult on footprint and stack height options for the expanded refinery. During the development of the LTRMS, new Ministerial Conditions were granted as part of the government’s approval of the proposed expansion of the Wagerup Refinery to 4.7 million tonnes per annum. Initially, this LTRMS aimed to address the new conditions (13-1 to 13-4 of Ministerial Statement No.728), which require the LTRMS to be revised prior to commencement of construction of the expansion and for the LTRMS to be independently reviewed. However during the period over which this report was written, firm timeframes for the expansion were not available, making development of footprint options over the current 25 year planning period difficult. In order to provide key stakeholders with further input on footprint options when the timing of the expansion is more certain, it is proposed to review the LTRMS again prior to commencement of construction of the expansion.

Key changes in environmental management and performance since the 2005 review were also presented; however the focus on routine operational environmental issues was reduced in recognition of the development of the Environmental Improvement Plan (EIP) process. The EIP process, implemented in 2006, is designed to address environmental improvement opportunities for the refinery and residue area. The EIPs for our WA operations are now reviewed triennially with local and government stakeholders.

2.5 Sustainability

In recent years Alcoa has focused on achieving a greater understanding of what sustainability means to the way it manages its business, and has developed an overarching framework for sustainable development. Alcoa’s drive to apply the framework and principles of sustainability is reflected in the emphasis of this document. The approach to residue management has expanded to embrace stakeholder engagement, with local community and stakeholders directly involved in the planning process. This has ensured that the concerns and queries of the local community, local government and regulatory authorities, and Alcoa’s response to these issues, are transparent and documented.

Alcoa’s approach to residue management is built on an overarching framework of sustainability. Alcoa defines sustainability as:

“using our values to build financial success, environmental excellence, and social responsibility in partnership with all stakeholders, to deliver long-term benefits to our shareholders, employees, customers, suppliers and the communities in which we operate” (Alcoa 2009).

This model views sustainability through three different, but interdependent lenses:

1. Sustainability of our products;
2. Sustainability of our resources; and
3. Sustainability of our operations.
This global sustainability model is represented in Figure 2-1. When making a business decision or developing a strategy, Alcoa aims to achieve simultaneous benefits across economic, social and environmental factors in order to achieve a net long-term benefit.

2.6 Alcoa's Stakeholder Engagement Process

Alcoa recognises that talking to communities, seeking input into plans, sharing environmental performance and understanding community needs is critical to maintaining its 'social licence to operate'. Consequently a range of informal and formal consultation methods have been employed by Alcoa to involve and inform the community of the company’s activities. The following section provides an overview of the current consultative groups in place at Wagerup and details of the process used to establish the 2012 Wagerup Refinery’s EIP.

2.6.1 Community Consultative Networks

Alcoa has established a Community Consultative Network (CCN) at Wagerup to provide an interactive and open forum that enables members of the community and Alcoa to freely discuss topics and issues relevant to Wagerup Refinery operations and the communities.

CCN is an open forum with all members of the community welcome to attend. Representatives from the towns of Yarloop and Waroona, and Local Government regularly attend these meetings. The CCN meets with Wagerup Refinery management and representatives on a monthly basis with an expectation that information obtained through the CCN is then shared with their wider community networks. Minutes of meetings are published in the local newspaper.

In 2004 the then Department of Environment (DoE) introduced a new initiative for WA industry: voluntarily adopt public Environmental Improvement Plans (EIPs). After Alcoa chose to produce an EIP for its Wagerup Refinery in 2005, a decision was made to utilise the CCN to provide guidance in the development of Wagerup Refinery’s EIP. During 2010, Wagerup Refinery’s EIP working group provided input and guidance during the development of the 2011 – 2013 EIP.

2.6.2 Environmental Improvement Program (EIP) Consultation Process

EIPs represent Alcoa’s public commitment to continuously improve environmental performance, reduce environmental impacts and develop more sustainable operating practices. In WA, Alcoa has voluntarily committed to produce EIPs. In many cases, the commitments within the EIPs go beyond the environmental management requirements specified in Alcoa’s formal licence conditions.

Wagerup Refinery released its first EIP in 2006. These plans are periodically updated in order to monitor progress against commitments and continuously improve our performance. The plans are currently updated triennially.

Alcoa recognises that input from stakeholders is vital, which is why several sectors of the community assist in the development of the EIPs. New environmental targets, aims and actions were established for the current EIP in consultation with the Wagerup Tripartite Group which includes community members, Alcoa employees and local and State Government representatives. The EIP sets clear targets for improvement and also outlines the actions and initiatives to be implemented to achieve those targets. The EIP forms part of Wagerup Refinery’s operational plan for 2011 - 2013.

The EIPs cover areas such as:

- Air quality, including dust, noise and odour;
- Waste management, including energy efficiency;
- Water conservation, including groundwater management;
- Land management, including visual amenity, rehabilitation and fauna/flora management; and
- Community involvement and environmental regulation.

2.7 Wagerup LTRMS Stakeholder Consultation Process

In the past, Alcoa’s residue planning has largely been an internal process with feedback incorporated from government agencies included. The first review of the LTRMS in 2000 broadened the consultation process to seek input from the local community on the proposed LTRMS. Government feedback was sought separately through the RPLG process.

Alcoa has further developed its consultation process for major developments and strategic planning process to an SRG process. This process involves formation of an advisory group, with affected stakeholder groups represented, to work with the company in developing of the LTRMS. This transparent process ensures the local and state government departments and community members have access to the same information from the company, and better understand each other’s issues and perspectives. The independently facilitated group works together to provide the company with a series of ‘guiding principles,’ or recommendations, for the company to consider in the development of the LTRMS.

The Wagerup LTRMS SRG is given an opportunity to review the draft LTRMS before it is presented to the RPLG for comment. Once the RPLG has endorsed the LTRMS, the document is submitted to the Minister for State Development. Input is then sought from the Minister for Environment before the Minister for State Development endorses the strategy.

The framework for stakeholder consultation in the LTRMS review for Wagerup Refinery is presented schematically in Figure 2-2.
2.7.1 Formation of the Wagerup LTRMS Stakeholder Reference Group

The 2012 Wagerup Refinery LTRMS SRG was formed in February 2012 and met fortnightly from March 2012 until May 2012. The process used to establish the SRG is outlined below.

2.7.1.1 Community Representation

To ensure adequate representation by community members on the SRG, a letter was sent to local residents in December 2011, inviting them to participate in the review of the LTRMS as a member of the SRG.

Advertisements were also placed in local papers inviting near neighbours, local business owners and those with a special interest in Alcoa’s residue operations to nominate.

All five community members who nominated were appointed to the SRG. Unfortunately one of the SRG’s community members resigned from the group early in the process due to personal circumstances, and another community member was unable to attend the meetings due to work commitments.

2.7.1.2 Government Representation

Local government representation was sought from the Shire of Waroona and Shire of Harvey who both nominated two representatives for the SRG – one elected and one staff representative. The Shire of Waroona elected representative did not attend any of the SRG meetings.

State government representation was sought and received from the Department of Environment and Conservation, Department of State Development, and Department of Planning. A representative from the South West Development Commission was also appointed to the group.

A representative from the Department of Health and the Peel Development Commission were invited to participate in the SRG process however no nominations were received. The Department of Health offered to provide any required information to the SRG upon request.

2.7.1.3 Alcoa Representation

Alcoa was represented on the LTRMS by its WA Residue Manager, David Honey, WA Residue Operations and Maintenance Manager, Matthew Cox, WA Operations Residue Environment Manager, Anika Wall, and Wagerup Refinery Community Relations Manager, Tom Busher.

Alcoa subject matter experts attended each meeting to present on the various topics.

Meeting reports were produced by the WA Operations Residue Environment Manager, Anika Wall.

2.7.2 Stakeholder Reference Group Terms of Reference and Operating Procedures

An independent facilitator, Andrew Huffer, was appointed to the Stakeholder Reference Group. The initial meeting of the SRG involved the clarification of the group’s role and operation in the LTRMS planning process. It was agreed that the responsibilities of the SRG are to:

- consider the long-term planning and strategic issues in residue management in areas such as health, dust suppression, water usage, compatible land use, residue reuse, rehabilitation, and impacts on neighbouring land;
• provide advice to Alcoa on factors that influence long-term residue management;
• provide a summary of their deliberations to be included in the development of the LTRMS; and
• conform to the Terms of Reference (TOR) agreed to by the SRG.

It was agreed to hold fortnightly meetings.

A list of agenda items and a proposed meeting schedule was developed for the SRG. Issues dealt with at SRG meetings were tabled in meeting reports. Between March and May 2012 seven meetings were held in the Waroona area to address the issues raised by the SRG.

### Table 2-2: Actual Meeting Schedule and Issues Addressed

<table>
<thead>
<tr>
<th>Affiliation</th>
<th>Name</th>
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<td><strong>Land Holders</strong></td>
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<tr>
<td>Community member</td>
<td>Jon Schupp</td>
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<td>Mike LeRoy</td>
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<td>Joanne Gunning</td>
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<td>Helen Alexander</td>
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<td><strong>Local Government</strong></td>
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<tr>
<td>Shire of Waroona</td>
<td>Cr John Salerian Mr Greg Delahunty</td>
</tr>
<tr>
<td>Shire of Harvey</td>
<td>Cr Greg Campbell Mr Simon Hall</td>
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<td>Department of Environment and Conservation</td>
<td>Lauren Trott</td>
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<tr>
<td>Department of State Development</td>
<td>Phil Knight Justine Steketee</td>
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<td>Aiden O’Brien</td>
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<td>WA Residue Manager</td>
<td>David Honey</td>
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<tr>
<td>WA Residue Operations and Maintenance Manager</td>
<td>Matthew Cox</td>
</tr>
<tr>
<td>WA Operations Residue Environmental Manager</td>
<td>Anika Wall</td>
</tr>
<tr>
<td>Wagerup Refinery Community Relations Manager</td>
<td>Tom Busher</td>
</tr>
</tbody>
</table>

Table 2-2 contains the actual meeting schedule and issues addressed by the group. Figure 2-3 shows members of the SRG, observers and guests at one of the meetings.

### 2.7.3 Key Outcomes of the Stakeholder Reference Group Process

As a result of the process undertaken 29 guiding principles were developed by the SRG over 14 topics. These guiding principles were considered by Alcoa and addressed, where possible, in the Wagerup LTRMS. The complete table of guiding principles, together with Alcoa’s response to them, are detailed in Section 10. Guiding principles on individual topics are also referenced throughout the body of the report, as appropriate.

### 2.7.4 Consultation Guiding Principles and Alcoa’s Commitments

In response to the information provided, the Wagerup LTRMS SRG developed three guiding principles relating specifically to stakeholder engagement. These are presented below, together with Alcoa’s response.

Several other guiding principles developed by the SRG requested community consultation in relation to specific activities. These consultation requests are noted in discussion on the areas to which they apply.

**Guiding Principle: Reporting on the Progress of the Guiding Principles**

Alcoa to provide an annual report on progress against the Guiding Principles to the Wagerup CCN. The updates to be provided every 12 months from the date of Ministerial endorsement of the 2012 Wagerup LTRMS.

**Alcoa’s Response**

Alcoa accepts and agrees with this principle.

**Guiding Principle**

Alcoa to document the feedback received from the annual reports for consideration in the development of the next Wagerup LTRMS.

**Alcoa’s Response**

Alcoa accepts and agrees with this principle.

**Guiding Principle**

Alcoa to use social media (where appropriate) and other communication
methods easily accessible by the local community and other stakeholders to communicate progress on the LTRMS.

**Alcoa’s Response**

Alcoa is committed to keeping the local community and other stakeholders informed about the progress of the LTRMS and the Guiding Principles. Alcoa considers the Alcoa website and CCN forums to be the most appropriate methods to ensure that this information is easily accessible; however social media and other communications methods will continue to be assessed.

<table>
<thead>
<tr>
<th>Meeting No.</th>
<th>Date</th>
<th>Topics Covered</th>
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<tbody>
<tr>
<td>1</td>
<td>2 March 2012</td>
<td>Introduction to LTRMS process, purpose, expectations and reporting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Overview of residue operations and site tour</td>
</tr>
<tr>
<td>2</td>
<td>16 March 2012</td>
<td>Environmental management – Part 1</td>
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<tr>
<td>3</td>
<td>30 March 2012</td>
<td>Residue reuse</td>
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<tr>
<td></td>
<td></td>
<td>Residue and health</td>
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<td>4</td>
<td>13 April 2012</td>
<td>Land Management – planning schemes, legislation and compatible land use</td>
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<td>5</td>
<td>27 April 2012</td>
<td>Residue storage requirements</td>
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<td>Criteria for selecting sustainable options</td>
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<td>Residue storage scenarios</td>
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<td>6</td>
<td>11 May 2012</td>
<td>Closure and final land use</td>
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<td></td>
<td></td>
<td>Finalise Guiding Principles</td>
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<tr>
<td>7</td>
<td>25 May 2012</td>
<td>Alcoa’s response to Guiding Principles</td>
</tr>
</tbody>
</table>

Table 2-2: LTRMS Stakeholder Reference Group Meeting Schedule.

Figure 2-3: Stakeholder Reference Group members, guests and observers at one of the meetings.
3.1 Overview
The Wagerup Refinery produces alumina from bauxite using the Bayer Process. The process involves four main steps: digestion, clarification, precipitation and calcination. In addition, two other important activities occur on site; the generation of power and steam for the Bayer Process, and the storage of bauxite residue (the material remaining after alumina is extracted) in impoundment areas known as RSAs.

The refinery water circuit is fully contained through recycling processes, with no discharge to the environment. Refer to Section 3.8 for a summary of the water circuit.

A schematic flowsheet of material processing from bauxite to aluminium is included in Figure 3-1.

3.2 Digestion
Bauxite is milled to sand size particles and hot concentrated caustic soda solution is added making a bauxite slurry. The hot caustic dissolves the available alumina within the bauxite. The hot “green” liquor is cooled from approximately 100°C to 60-75°C and seed alumina hydrate crystals added, causing alumina hydrate to crystallise. The liquor and hydrate are separated. The hydrate crystals are sized, and crystals of a suitable size removed. Undersized hydrate crystals are returned to the process as seed crystals.

3.3 Clarification
Sand and clay (red mud) are settled out leaving an alumina rich “green” liquor. The settled out sand and mud are washed and then pumped out separately to the residue area.

3.4 Precipitation
The hot “green” liquor is cooled from approximately 100°C to 60-75°C and seed alumina hydrate crystals added, causing alumina hydrate to crystallise. The liquor and hydrate are separated. The hydrate crystals are sized, and crystals of a suitable size removed. Undersized hydrate crystals are returned to the process as seed crystals.

3.5 Calcination
Sized hydrate is washed and dried, then heated to 1000°C to drive off chemically bonded water leaving aluminium oxide (alumina).

3.6 Power and Steam Generation
Power and steam requirements for the refinery are met by an on-site power station. The primary fuel supply for the power station boilers is natural gas. Diesel is available as a back-up fuel supply.

3.7 Residue and Waste
The material remaining after the alumina has been extracted from the bauxite ore is commonly termed “residue”. Residue is produced at a rate of approximately two dry tonnes per tonne of alumina. This material is stored at the residue area adjacent to the refinery.

The residue consists of a coarse sand fraction (often termed ‘red sand’) and a fine silt fraction (often termed ‘red mud’). Approximately 37% of the residue stream is sand and 63% is mud. The mud density is increased at the residue area by thickening prior to its final discharge into residue drying areas. The sand is stockpiled and subsequently used for internal construction activities at the residue storage area. Oxalate, another
A number of other facilities that support the refining operations are located in the residue area. These include ponds designed to cool refinery process liquor (cooling pond) and to store rainfall runoff water from both the refinery site and residue area (run-off water storage (ROWS) pond). The ROWS pond is designed to contain the accumulated runoff from a 1:100 wet year. Water is recycled back to the refinery via the cooling pond.

### 3.8 Refinery Water Circuit

The Wagerup Refinery has used an average of 3.54 kilolitres (kL) of water per tonne of alumina product each year since 2007. The refinery operates a closed water circuit, which is supplemented for water losses. Losses of water primarily occur as steam from the process, evaporation from water storage areas and residue surfaces, and water bound within the residue mud and sand. Make-up water is primarily taken from licensed groundwater sources and Water Corporation supply. Onsite sources of make-up water include water contained in the caustic soda, moisture in bauxite, groundwater recovery bores and rainfall runoff. All rainfall runoff from the refinery site and RSAs is captured, stored in lined ponds and recycled back into the refinery process.

Residue area water management is discussed in more detail in Section 7.8.

*Figure 3-1: From bauxite to aluminium schematic flowsheet.*
Early bauxite residue management processes involved the deposition of residue mud as dilute slurry into storage areas – termed ‘wet’ disposal.

4.1 Overview
In 1991, Wagerup Refinery adopted an alternative storage technology termed ‘dry stacking’. This process involves pre-thickening the residue mud and then depositing it in layers which are dried through solar evaporation. The process is assisted by physically turning over the mud, and produces a high-density, stable stack of residue upon which the next mud layer can be placed.

Dry stacking of residue is fully operational at all three of Alcoa’s Western Australian refineries, and this type of storage is now being adopted by other minerals industries as a best practice. The advantages of this method include:
• a significantly reduced footprint;
• reduced environmental risks, such as groundwater impact; and
• a more stable landform that enables direct rehabilitation and a wider range of potential future land uses.

In 1990, a detailed report of the proposed residue drying operation for Wagerup was submitted to the Minister for Environment (Alcoa, 1990). This report formed the basis for government approval of the changes to residue management. Operating experience gained at Pinjarra, Kwinana and Wagerup, and continual improvements to the methods of RSA construction, have provided a sound basis on which the original residue management strategies can be updated. Alcoa is now able to project, with confidence, the facilities required to sustain the dry stacking operation well into the future.

Alcoa believes the bauxite reserve in Mineral Lease 1SA will sustain the company’s operations for at least another 50 years. During this time, it is anticipated that alumina production will become more efficient and residue reuse options will assist in reducing the volume of residue to be stored. For the purposes of this planning process, the life-of-mine is considered the life of the current lease (2045). However, given the capacity of the mine and renewal options on the bauxite lease, at present the exact date of closure and volume of residue requiring storage remains uncertain.

As at December 2011, the total residue storage operation footprint at Wagerup, including water storage facilities, was 592 hectares and the maximum residue height was 29 meters above natural ground level (RL 43 m). The residue footprint expansion is planned to the west of the current footprint within the next five years. The rate of expansion of the residue footprint will depend on the actual production rates over time and the height of the stack. The height of the residue storage area will also influence the direction and timing of the footprint expansion; a higher stack height allows the footprint to be contained to a smaller overall footprint.

4.2 Residue Characteristics
4.2.1 Chemical Condition
As described in Section 3.1, bauxite is crushed, ground and leached with a caustic soda solution during the alumina refining process. The remaining residue
consists of both solids and entrained alkaline solution. During alumina extraction, raw caustic soda solution, lime, and small quantities of chemical reagents are added. Side reactions occur which form small quantities of alkaline solids in the residue (Alcoa, 1997).

From an environmental viewpoint, the alkalinity of the bauxite residue imparted by the addition of caustic soda and lime is of most note. Typically, the solution entrained with the residue has a total alkalinity of between 20 and 30 grams per litre (g/L) expressed as sodium carbonate, and a pH of 13. Specifically, the alkalinity of the residue affects the mud drying rate and the dusting potential of the residue surface. Alcoa has developed a process to reduce the pH of the bauxite residue to around 10.5 by reacting the residue slurry with carbon dioxide. This process, termed ‘carbonation’, has been fully implemented at Kwinana, however the lack of a financially viable source of carbon dioxide at Wagerup has delayed implementation at that site. See Section 4.6.3 for details.

4.2.2 Physical Condition
Bauxite residue is composed primarily of iron and silica minerals. Residue from Darling Range bauxite is characterised by a high coarse fraction, due to silica in the bauxite. The coarse fraction can be considered as a fine to medium grained sand with a specific gravity of 2.9. This residue sand has proved to be an ideal material for embankment and road construction within the dry stacking operation, as a free draining material suitable for surface rehabilitation, and for the construction of drainage layers at the base of the RSAs (Alcoa, 1997).

The fine fraction of the residue, commonly termed ‘red mud’, is silt to clay sized material with a specific gravity of 3.2. The higher specific gravity of the fine fraction results from the relatively high iron content. This fine fraction settles very slowly and has little strength unless dewatered or dried. When in slurry form, the fine fraction must be contained within approved engineered embankments (Alcoa, 1997).
4.3 Physical Structure of Storage Areas

A schematic diagram of the dry stacking process used at Alcoa’s residue area is presented in Figure 4-1.

The fine tailings are pumped to a thickener vessel where they are settled using flocculent, producing high-density underflow slurry of 40 to 50% weight for weight (w/w) solids. This slurry is pumped to one of a number of RSAs where it is placed in layers and allowed to dry through evaporation. To assist the natural drying process, the surface of the RSAs are mechanically turned over using bulldozers and amphirols. The final dry density of the tailings is around 70% solid material. This compares to the final density of 60-65% solids typically achieved using earlier wet disposal methods.

The coarse tailings (residue sand) are used for construction of embankment walls, drainage layers, rehabilitated surfaces and roads within the residue area.

4.4 Footprint Design

The two main factors affecting the design of the residue area are the volume of mud to be stored and the open area required to dry the mud. Careful planning, considering direction, height and timing is required.

The volume of mud required to be stored depends on the rate and timeframe over which residue is produced. The volume of a stack is a result of the footprint geometry and the height of the stack. The geometry of the stack (embankments and internal dyke slopes) is influenced by structural stability and visual amenity requirements. A lower stack height requires a larger area of land to store the same volume of mud.

Figure 4-1: Coarse particles are separated from fine tailings using cyclones and counter-current wash towers.

Figure 4-2: Schematic diagram of the dry stacking process.
Available drying area is a function of length and width of the open stack, less the internal areas taken up by dykes and infrastructure. As the mud elevation in drying areas increases over time, perimeter embankments progressively move inwards and the net available drying area reduces. As a consequence, to maintain the minimum drying area required to dry mud it is necessary to periodically construct new drying areas.

Figure 4-2 illustrates the process of developing the overall stack. Area A would need to be built and filled before you can start to build B, and similarly Area C would need to be built and filled before you can create a new area D.

### 4.5 Construction of New Residue Facilities

Prior to the design of a new residue facility, the area concerned is subject to a detailed site investigation that includes an evaluation of geotechnical and hydro-geological conditions. A preliminary design report is prepared for each new residue area 6 to 12 months prior to the commencement of construction and forms the basis for government agency review and environmental approval.

The RSAs are designed in accordance with the applicable edition of “Tailings Management” (2007) issued by the Department of Industry, Tourism and Resources, and guidelines produced by the International Commission on Large Dams (ICOLD) and the Australian National Committee on Large Dams (ANCOLD). These guidelines include design criteria for earthquake risk, long-term stability and management of storm events.

In addition, Alcoa has mandated standard internal design guidelines for all new RSAs in Western Australia to ensure the risk of ground and surface water contamination is minimised. These standards require all new residue areas to have:

- a constructed low permeability base and embankment seal that is equivalent to approximately 0.45 metres depth of mechanically compacted clay with a hydraulic conductivity of less than 10-9 m/sec,

a synthetic geo-membrane (HDPE) placed directly on top of the clay seal;
- a base drainage system which reduces the hydrostatic pressure on the seal above the ‘composite liner’ referred to above;
- monitoring systems to indicate leakage or spillage outside of the containment system;
- a containment system to prevent uncontrolled and/or untreated discharge of contaminated runoff from the RSA (note: the existing ROWS pond is designed to cater for run-off generated from the residue system as a whole during a 1:100 wet year);
- design and layout to minimise the risk and impact of spillage from pipelines and pumping systems including primary and secondary spillage containment structures at high risk areas; and
- embankment design to ensure long-term stability against slippage and erosion including thorough assessment of the risks and effects of dynamic loads such as earthquakes. Factors of safety are adopted in accordance with the guidelines.

Residue areas are subject to inspection by an independent consultant every year to ensure that they are being constructed and operated correctly. If the independent consultant recommends further stability investigations, stability assessments are carried out using a cone penetrometer (CPT) which gives a profile of material strength by measuring the resistance generated by forcing a probe through the residue stack. The results are used to generate a factor of safety for the stack configuration. If stability issues are suspected, detailed geotechnical studies are carried out and corrective actions are implemented to ensure ongoing adequate stability.

#### 4.5.1 Borrow Materials

The construction of future RSAs requires mining of low permeability clay to line the base of the residue deposit. This clay is generally mined from available deposits on Alcoa’s property near the current residue footprint and borrow areas are either rehabilitated when the resource is exhausted or converted for use as part of the residue facilities, such as water storage.

#### 4.6 Bauxite Residue Research and Development Activities

##### 4.6.1 Overview

Development of alternative uses for bauxite residue has been one of the major objectives of Alcoa’s residue research program since 1978. By identifying and demonstrating a range of technically and economically feasible alternative uses, bauxite residue may be considered a stored resource. The company also recognises that if significant reuse can be achieved, the rate of expansion of the residue area can be slowed, and the long-term impacts of residue storage can be reduced.

##### 4.6.2 Reuse Strategies

Alcoa has examined a range of potential uses for bauxite residue, including:

- as a soil amendment for broad acre farming and horticultural uses;
- as a sand for use in cement manufacture;
• in effluent treatment ponds and septic systems;
• for trace metals retention from road runoff, rubbish tips and acid mine drainage;
• as a pigment;
• in ceramic manufacturing;
• in plastics manufacturing;
• for top dressing recreational ovals;
• as a golf course bunker sand;
• for industrial land development; and
• in road base.

Alcoa works closely with external research facilities, funding collaborative and contract research projects with a number of CSIRO divisions and universities such as the University of Western Australia, Murdoch University, Curtin University of Technology, Sydney University of Technology, Royal Melbourne Institute of Technology, University of New South Wales, University of South Australia, Monash University and the University of Queensland.

After reviewing the broad range of potential uses listed above, two potential products (ReadyGrit® and Alkaloam®)

It is currently proposed that ReadyGrit® be used for applications such as top dressing of turf for recreational uses, road construction, and industrial land development. ReadyGrit® is well structured and has phosphate retention properties. It has also been assessed as a growth medium for turf production, as a top dressing soil for golf courses, for use in concrete production and as a general fill material for land reclamation.

ReadyGrit® produced at a pilot plant at Alcoa’s Wagerup Refinery was used by the Department of Main Roads in a road construction trial on Greenlands Road, and by Fairbridge Village to top dress its main oval (both in Pinjarra, Western Australia). ReadyGrit® from Alcoa’s Kwinana Refinery has been used to top dress the Alcoa Social Club oval, in a series of trials with various golf clubs, and at an industrial land development trial in conjunction with Landcorp.

A number of independent assessments have been completed on ReadyGrit® and the reports from these assessments have been submitted to the relevant government agencies. A radiological assessment has been completed by a well recognised expert in this field (Professor Brian O’Connor), and the report from this assessment has been approved by the Radiological Council of Australia. A health risk assessment has been completed by Toxikos, toxicology consultants, and the report has been approved by the Western Australian Health Department.

The use of Alkaloam® has been recognised as a Best Management Practice (BMP) by the Environmental Protection Agency (EPA) in the Peel-Harvey Water Quality Improvement Plan, developed under the Coastal Catchments Initiative (federally funded monies targeting water quality improvement in sensitive catchments).

The Centre for Sustainable Resource Processing (CSRP) commissioned URS and the Centre for Social Responsibility in Mining (CSRM) from the University of Western Australia (DAFWA), has investigated the possible widespread use of Alkaloam® as a soil amendment in the Peel-Harvey Catchment to mitigate nutrient export into the Peel-Harvey Estuary, where nutrient levels are high. Results demonstrate that, following the addition of Alkaloam®, phosphorous losses from farmland can be reduced by as much as 90%. Consequently, increases in pasture productivity of about 25% can also be achieved.

Alcoa has developed a Memorandum of Understanding with a potential joint venture partner to assess the long-term feasibility of the ReadyGrit® project. The potential joint venture partner is planning to expand its market assessment in 2013 in preparation for potential full-scale plant construction in 2014 and production by 2015. The joint venture partner brings a high level of knowledge and experience in the technology associated with the mineral sands industry, and has a strong marketing presence to develop the market in the proposed applications.

4.6.2.2 Alkaloam®

Alkaloam® is the fine-grained residue often referred to as ‘red mud’. Significant work has been done to show the benefits of adding this material to sandy soils (common in coastal regions of WA) to elevate the pH of acidic soils and retain phosphorous, reducing overall fertiliser use and protecting sensitive waterways.

Alcoa, in conjunction with the Department of Agriculture and Food, Western Australia (DAFWA), has investigated the possible widespread use of Alkaloam® as a soil amendment in the Peel-Harvey Catchment to mitigate nutrient export into the Peel-Harvey Estuary, where nutrient levels are high. Results demonstrate that, following the addition of Alkaloam®, phosphorous losses from farmland can be reduced by as much as 90%. Consequently, increases in pasture productivity of about 25% can also be achieved.

The Centre for Sustainable Resource Processing (CSRP) commissioned URS and the Centre for Social Responsibility in Mining (CSRM) from the University of
Queensland to perform a Sustainability Assessment on the use of Alkaloam® on agricultural land. The key tasks of this review were to undertake community consultation, a consolidated safety and technical review of previously conducted research and assessments, and a cost benefit analysis of the commercial use of bauxite residue.

The Swan River Trust, in partnership with the DAFWA and ChemCentre, has begun testing the effectiveness of adding various industry by-products to soil to help reduce nutrient loads entering the Swan Canning river system from agricultural land. Three nutrient sorbent materials – Lime Amended BioClays® from the Water Corporation, Iron Man Gypsum® from Iluka and Alkaloam® from Alcoa – are being tested in the trial. The information from the trial will be used to identify the most appropriate rates to apply each of the materials to agricultural lands and how effective the by-products are in retaining nutrients in soil to be used by pasture crops. The trial has been structured to reflect the level of detailed investigation required to be undertaken by the manufacturer or providers of these materials to ensure environmental integrity.

4.6.3 Carbonation
As well as investigating alternate uses of residue, Alcoa has researched strategies to improve the characteristics of residue. Residue carbonation involves the addition of carbon dioxide (CO₂) to thickened residue slurry to lower the pH of the residue, from pH 13 to a pH of less than 10.5. Neutralising the pH promotes natural biological activity, which facilitates the breakdown of organics in the residue. The process is an accelerated version of the natural process that occurs when carbon dioxide in the air reacts with residue.

Carbonation is preferred to other neutralisation options, as this method doesn’t introduce impurities into the refining process, therefore the closed water circuit can be maintained. The benefits of carbonation include:

- improved quality of run-off and drainage water, lessening the potential for environmental impacts from the residue operations;
- surface less prone to dusting;
- improved drying rates resulting in less drying area required;
- deferral of construction of new areas, which has a cost and aesthetic benefit;
- greenhouse benefit through the use of residue as a sink for CO₂ (the net CO₂ sequestered takes into account the influence of bio destruction of organics); and
- improved re-use opportunities.

Alcoa has completed the full-scale implementation of carbonation at Kwinana where waste CO₂ from the CSBP ammonia plant is being utilised. At Wagerup, a source of high concentration CO₂ is currently unavailable. Alcoa reviewed the potential to extract CO₂ from the powerhouse or calciner gas streams using a solvent extraction process. This process was not financially viable, but the company is continuing to evaluate alternative CO₂ sourcing options. One potential option is linked to a current Western Australian State Government initiative which is investigating the potential for geo-sequestration of CO₂ in the South West of Western Australia (the Collie Hub project). An initial phase of this project could see a pipeline installed between Kwinana and the proposed geo-sequestration site south of Wagerup to run a test well over several years. This same pipeline could potentially be used to deliver CO₂ to the Wagerup and Pinjarra refineries for Alcoa’s residue carbonation.

Because sourcing CO₂ is currently uneconomic in many locations, Alcoa’s previous global research and development goal for all new residue to be treated to below a pH of 10.5 by 2010 is no longer current. However residue carbonation is still a long-term corporate aim.

4.6.4 Residue Reuse Guiding Principles and Alcoa’s Commitments
In response to the information provided, the Wagerup LTRMS SRG developed three guiding principles related to alternate uses for residue. These are presented below, together with Alcoa’s response.

Guiding Principle: ReadyGrit®
Alcoa to urgently pursue all necessary approvals for the use and commercial production of Red Sand (ReadyGrit®).

Alcoa’s Response
Alcoa accepts and agrees with this principle. Seeking approval for the use and commercial production of ReadyGrit® is a key objective for Alcoa, however various factors including economic, operational, and regulatory impacts may impede progress of this action.

Guiding Principle
Alcoa to identify sustainable markets for the use of ReadyGrit®, including business modelling to identify sources and location of demand.

Alcoa’s Response
Alcoa accepts and agrees with this principle. Seeking approval for the use and commercial production of ReadyGrit® is a key objective for Alcoa, however various factors including economic, operational, and regulatory impacts may impede progress of this action.

Guiding Principle: Alkaloam®
Alcoa to continue to undertake further research and identify other opportunities for the use of red mud (Alkaloam®).

Alcoa’s Response
Alcoa accepts and agrees with this principle.
5 economic and social setting

5.1 Description of the Local Community

The Wagerup Refinery is located 120 kilometres south of Perth and is located close to the southern boundary of the Shire of Waroona, bordering with the Shire of Harvey. The Shire of Waroona is part of the Peel Region, and the Shire of Harvey is part of the South West Region. The nearest townships to the refinery are Hamel (located 2 kilometres north of the refinery within the Shire of Waroona) and Yarloop (located 2.5 kilometres south of the refinery in the Shire of Harvey). The nearest regional centre is Waroona, located approximately 7 kilometres north of the refinery.

The Shire of Waroona covers an area of 835 square kilometres. The Shire has a population of 3,889 (Australian Bureau of Statistics, 2012), which is 3.4% of the Peel Region (Peel Development Commission, 2012). The Waroona town site is increasing in size each year due to a steady growth in new housing development. Alcoa is the principle employer of Shire of Waroona residents (Shire of Waroona, 2010).

The Shire of Harvey covers an area of 1,766 square kilometres. The Shire has a population of 24,901 (Australian Bureau of Statistics, 2012), which is 15% of the South West Region. The Shire of Harvey is currently experiencing rapid growth (Shire of Harvey, 2011). An overview of Alcoa’s economic and social contribution to the Shires of Waroona and Harvey is provided in Section 5.3.

5.2 Social Assessment Review

Stakeholder Perception Surveys (SPS) are conducted every two years. Alcoa recognises that its stakeholders can greatly influence the speed, ease and success of its current operations and future plans for growth. It is important to the company to have a clear understanding of the expectations and perceptions held by our key stakeholders across our operations.

The SPS measures seven key dimensions:

- **Social License** – a measure of credibility and legitimacy, and is the degree to which Alcoa’s presence is accepted and supported.
- **Social Capital** – the stock of active connections as measured by trust, mutual understanding and shared goals.
- **Social Justice** – the degree to which Alcoa utilises procedures that are ethical, consistent and inclusive (procedural), and that demonstrates respect when explaining actions and disseminating information (interactional).
- **Satisfaction** – a measure of the quality of relationships, how well Alcoa deals with issues, and is influenced by honesty and transparency.
- **Reputation** – heavily influenced by motivation to collaborate and keeping promises.
- **Communication** – how effective Alcoa is at communicating its vision and values and looks at frequency, medium, and clarity.
- **Performance** – an overall rating
across social, environmental and financial areas.

Key outcomes from the 2012 Wagerup survey revealed:

- The level of satisfaction with relationships with Alcoa personnel improved since 2010 (when the survey was last completed);
- Almost half of respondents indicated that their relationships with Alcoa are getting better;
- Respondents perceive Alcoa’s reputation to be improved when compared to 2010 results; and
- Respondents believe the effectiveness of Alcoa’s communications have improved since 2010.

5.3 Overview of Alcoa’s Economic and Social Contribution

5.3.1 Economic Contribution

Alcoa contributes to the economy directly through spending on goods and services and by paying salaries and wages to its workforce. Alcoa also contributes indirectly through flow-on spending. Each year, Alcoa contributes more than AUD$2 billion to the WA economy through wages and salaries, taxes and royalties, and the purchase of goods and services.

Wagerup Refinery and Willowdale Mine have a combined workforce of approximately 900 full time employees. Of these 30% live in the Shires of Waroona and Harvey.

Alcoa encourages local suppliers to conduct business with the company and the refinery. It invites local businesses to bid on locally supplied or manufactured goods or services and gives preference to local business in a competitive situation. Alcoa also works with local business groups to identify and utilise local suppliers and where possible, structures bids to enable local supplier participation.

5.3.2 Wagerup Meeting Global Demand

During the past 40 years Alcoa has grown into one of Australia’s major mineral exporters. Alcoa of Australia operates the largest integrated bauxite, alumina refining and alumina smelting system in the world. The Wagerup Refinery is currently one of the world’s most efficient alumina refineries. In order to maintain its global competitiveness Alcoa is pursuing ways to further improve efficiencies and increase production to meet global demand at its existing operations, as well as investigating potential new projects.

5.3.3 Partnerships and Volunteering

Wagerup Refinery contributes to the local community through its partnership and volunteering programs in the areas of environment, leadership, health and safety, and building community capacity. The Wagerup Refinery has several key partnerships in each of these areas and also supports local community events. Some of these key partnerships are outlined below.

Lot 208 Youth Program

Wagerup Refinery provides financial support to the Lot 208 Youth Program based in the Shire of Harvey which operates in Australind and provides important outreach services to other venues dealing with teenagers. The organisation provides regular support services and holiday programs for youth.

School Related Initiatives

Alcoa supports local schools through the provision of the Blue Earth program, St John Ambulance First Aid Training Courses, School Award Evenings and by the granting of small scale funding tailored to each school’s curriculum priorities.

Yarloop Community Grants Program

In partnership with the Shire of Harvey Alcoa has operated the Yarloop Community Grants Program which has funded programs and upgrades to facilities at the Log Fence Pony Club, Rifle Range, Yarloop Workshops, Masonic Lodge, CWA, Bowling Club, Yarloop Community Resource Centre, Skate Park, Primary School and Bushfire Brigade.

Bunbury Regional Entertainment Centre (BREC)

BREC is the major concert facility in the South West region. Located in Bunbury it provides an essential service to the arts and cultural community of the area. Alcoa has committed itself for a three year deal to support the operations of the centre.

Community Festivals and Events

Alcoa provides financial support to annual festivals held in the local community including the Shire of Waroona’s Summer Series, Harvey Mainstreet, Bunbury Multicultural Concert, South West Local Government Emergency Forum and the Harvey and Waroona Agricultural Shows.

Employee Volunteers

Alcoa also provides support to Alcoa employees who volunteer with local community organizations grants of $250 per person for up to three community groups. In 2011 around 43% of Wagerup employees accessed this initiative facilitating payments of more than $100,000 to local community groups.
environmental, heritage and planning setting

6.1 Climate
Wagerup has a Mediterranean type climate characterised by warm dry summers and mild wet winters. Detailed climatic data is available from the Bureau of meteorology monitoring location at Wokalup, approximately 22 kilometres south of the Wagerup Refinery.

6.1.1 Temperature and Humidity
Wagerup temperatures are characteristic of the south west region of Western Australia, and are similar to Perth. The warmest months at Wagerup are January and February, when maximum temperatures average over 30 degrees and can exceed 40 degrees (Bureau of Meteorology, 2012). The coldest months are July and August, when the average maximum temperature is around 17 degrees.

Humidity at Wagerup generally peaks in the early mornings and drops during the day. Humidity is higher in winter than summer.

6.1.2 Rainfall
Annual rainfall near Wagerup Refinery averages 944.4 millimetres. On average, rainfall is recorded on 60 days each year. Approximately 75% of the total annual rainfall is recorded between May and September. Although most of the annual rainfall falls in the winter months, the highest daily rainfall totals have occurred during the summer months (Bureau of Meteorology, 2012).

6.1.3 Wind
Winds at Wagerup are controlled by synoptic weather patterns, local features such as the topography, and sea and land breezes. During the summer months, easterly winds are generated from high pressure systems passing over the south west corner of the state. In winter, westerly winds are caused by cold fronts and low pressure systems. Wagerup Refinery is located at the base of the Darling Scarp. This topographical feature:

- Generates very strong local winds during summer, particularly at night and in the early morning. These winds are known as gully or foothill winds.
- Creates rotors or wind reversals near the foothills during easterly winds.
- Channel or deflect westerly winds up the escarpment.
- Create katabatic flows down the escarpment.

6.2 Topography
Wagerup Refinery is located at the foot of the Darling Scarp where the land slopes gently towards the west. The residue area and surface water detention pond are constructed on the Pinjarra Plain. The natural ground level at the residue area is approximately 15 meters above sea level (15 metres AHD or RL).
6.3 Hydrology

6.3.1 Groundwater

The superficial geological formations in the region are heterogeneous, comprising zones of very permeable clay, sandy clay, laterite and sand. Under the refinery and residue areas, the superficial formations can generally be divided into an upper layer with low permeability and a lower layer with higher permeability. For simplicity, these layers are referred to as the upper and lower superficial formations.

Below the residue area, the low permeability clays and sandy clays of the Guilford Formation generally restrict vertical groundwater movement in the superficial aquifer. This is underlain by sands and clayey sands of the Yoganup and Ascot Formations. These sandy formations intercept and together form a regionally continuous aquifer, which is the main conduit for horizontal groundwater movement in the superficial formations.

This aquifer is confined by the less permeable, overlying clayey materials of the Guildford Formation.

The contact between the Leederville and Yoganup formations is generally identifiable due to a layer of carbonaceous or greenish-grey silty clay and shale. This layer restricts the vertical movement of groundwater between the superficial formations and the underlying Leederville Formation. The various geological formations are illustrated in Figure 6-1.

Groundwater salinities in the Wagerup area range between about 500 mg/L and 5,000 mg/L. The most saline groundwater generally occurs in the Guilford Clay, and this is a consequence of evapotranspiration processes. Groundwater in the underlying Yoganup Formation, Ascot Formation and the upper parts of the Leederville Formation generally has salinities less than 1,500 mg/L.

6.3.2 Surface Hydrology

The Wagerup Refinery area is within the lower reaches of the Harvey river catchment, which is the largest catchment draining into the Peel-Harvey Estuary. The main river system in this catchment is the Harvey River, which lies approximately 4 kilometres to the west of the refinery and flows in a north-westerly direction, discharging into the Harvey Estuary.

The North Yalup Brook and Lower Yalup Brook are located to the north of the refinery, and Bancell Brook to the south of the Refinery. Overflow from the fresh water catchment dams and ponds on Alcoa’s property flows into the South Samson Diversion Drain which flows along the eastern and southern sides of the residue area and drains into the South Samson Drain (See Figure 6-2), which ultimately discharges into the Harvey Estuary.
There are no Environmental Protection Policy (EPP) listed wetlands in the immediate vicinity of the Wagerup Refinery or residue area. There is one EPP listed wetland located approximately 1 kilometre south of the residue area, on the northern side of Bancell Road. This wetland, often referred to as Exelby Wetland, was traditionally an ephemeral wetland, however due to the inflow of excess irrigation water from surrounding farmland, it has become a permanent water body. Other nearby wetlands include four small wetlands near Yarloop (located approximately 3.5 kilometres south of the refinery), and three small wetlands near Hamel (located approximately 4 kilometres north of the refinery).

6.4 Flora and Fauna

6.4.1 Flora

The area surrounding the Wagerup Refinery is predominantly rural, with most of the region cleared for agriculture (ENV Australia, 2008). The vegetation surrounding the Refinery and residue areas now consists of pasture grasses and a mixture of Eucalyptus trees and shrubs. Alcoa owns approximately 6,000 hectares of the surrounding rural property and this land is predominantly operated as a beef farming enterprise by Alcoa Farmlands.

ENV Australia (2008) described the area where the Wagerup refinery and residue areas are located as the Drummond Botanical subdistrict, which prior to clearing consisted mainly of the following vegetation communities:

- Banksia Low Woodland on leached sands;
- Melaleuca Swamps in poorly drained areas;
- Tuart (Eucalyptus gomphocephala) Woodland; and
- Jarrah (Eucalyptus marginata) and Marri (Corymbia calophylla) on the less leached soils.

The majority of the trees located near the residue area have been planted as wind breaks and generally occur along fence lines and roads.

Figure 6-2: Local and groundwater flows.
Some remnant stands of native vegetation remain near the Refinery. These remnant areas are mostly confined to road verges (Mattiske, 2011) and vary in condition from Very Good to Completely Degraded, with weed infestation the most common degrading factor (ENV Australia, 2008). Alcoa commissions consultants to undertake periodic flora and vegetation surveys of selected remnant bushland areas on the Alcoa Farmlands adjacent to the Wagerup Refinery. The information collected from these surveys is used to guide future conservation and rehabilitation work in the farmland areas.

Elements of two Threatened Ecological Communities (TECs) are found within the Alcoa Farmlands area: Corymbia calophylla (Marri) – Kingia australis (Kingia) woodlands on heavy soils of the Swan Coastal Plain, and Corymbia calophylla (Marri) – Eucalyptus marginata (Jarrah) woodlands on sandy clay soils of the southern Swan Coastal Plain.

Alcoa protects, restores and enhances the remnant bushland areas located on the Alcoa Farmlands. This is achieved through fencing off areas, planting native species, eradicating exotic species and working with local land care groups including the Peel Harvey Catchment Council, Harvey River Restoration Trust and Harvey Water.

6.4.2 Fauna

6.4.2.1 Habitat

There are typically four habitat types on the land surrounding the Wagerup Refinery. These are wetlands, drainage lines, shrublands and woodlands.

The wetland habitat areas consist of both open water habitats and damp lands. These areas are typically characterised by trees over a weed understorey. Several sites within the Alcoa Farmland area are in a good to very good condition with shrubs and sedges that provide shelter and habitat for mammals, reptiles, amphibians and birds (ENV Australia 2009).

Drainage line habitats consist of both man-made and natural drainage lines that are usually dominated by weeds up to the water’s edge and trees (mature Melaleuca species, Eucalyptus rudis and Corymbia calophylla). The trees offer habitat for avifauna and arboreal species. Some drainage lines have an understory and good litter cover that provides habitat for ground-dwelling fauna, and soils suitable for burrowing species (ENV Australia, 2009).

Only a few shrubland habitats are present around the Refinery and residue areas, and these primarily consist of only Xanthorrhoea species (Grass trees) over weeds and offer limited habitat value (ENV Australia, 2009).

Woodland habitats around the refinery and residue areas are dominated by trees with minimal understory. These areas are therefore of most habitat value to avifauna with a small number of ground dwelling mammals and reptiles because of the lack of shelter for these animals. These woodland areas lack tree hollows, hollowed out logs and leaf litter (ENV Australia, 2009).

6.4.2.2 Recorded Fauna

Historical records, habitat assessments and fauna surveys indicate that a total of 287 fauna species potentially occur in the areas surrounding the Wagerup refinery and residue areas. This comprises of 32 mammal species, 56 reptile species, 15 amphibian species and 184 bird species (ENV Australia, 2009). The natural remnant vegetation areas provide habitat most suited to birds, with very few mammals, reptiles and amphibians likely to be present.

Fauna of conservation significance has previously been recorded near the Wagerup refinery and residue areas (Environmental Management and Research Consultants, 2005). This fauna includes:

- Southern Brush Tailed Phascogale (Phascogale tapoatafa);
- Southern Brown Bandicoot (Isodon obesulus fusciventer);
- Western Brush Wallaby (Macropus irta);
- Water Rat (Hydromys chrysogaster);
- Baudin’s Cockatoo (Calyptorhynchus baudinii); and
- Brush Bronzewing (Phaps elegans).

Carnaby’s Black Cockatoo (Calyptorhynchus latirostris) are also known to occur in the region, however they have not been identified in surveys of the Alcoa owned areas.

Two of the mammal species recorded in the area are introduced, the European Red Fox (Vulpes vulpes) and the rabbit (Oryctolagus cuniculus). Foxes prey on and compete with native fauna, and rabbits can cause extensive damage to vegetation through grazing (ENV Australia, 2009).

6.5 Heritage Sites

6.5.1 Aboriginal Heritage

Prior to European settlement, the area near the Wagerup Refinery was used by the Noongar Aboriginal people, who moved across the South West of Western Australia.

Surveys of heritage sites are carried out prior to any proposed changes to the refinery and residue footprint. These surveys are conducted according to the Guidelines for Aboriginal Heritage Assessment released by the Minister for Aboriginal Affairs in October 1993, and the survey reports are prepared in accordance with the Guidelines for Preparing Aboriginal Heritage Survey Reports.


There are two registered aboriginal heritage sites within the vicinity of the Wagerup refinery and residue area. One site is located outside the southern edge of the existing residue area, and the other
is within the refinery boundary. Both sites have artefact scatters that are believed to have originated from a camp that was located in the area (Government of Western Australia, 2012). The long-term residue footprint will not impact on any known archaeological sites.

6.5.2 European Heritage
The area around Waroona was first settled in the 1880s. The area was a timber district initially however dairy soon became the major industry of the area (Anne Jennings and Associates, 2006).

The local area has a rich ethnic diversity. Significant numbers of Italian, Yugoslav and other European migrants have settled in the area and the Italian culture remains very strong today.

There are no known European heritage sites located within the current planned long-term residue footprint area.

6.6 Existing Land Use and Tenure
Alcoa's land holdings include the land required for current and future residue areas, refinery activities and surrounding farmlands. The extent of Alcoa's land holdings are shown in Figure 6-3.

Part of Alcoa's land holdings are zoned as "industrial" to allow for operation of the refinery and residue areas. The current industrial boundary is shown in Figure 8-1.

Alcoa's future plans for residue storage areas are discussed in Chapter 8.

6.6.1 Alcoa's Land Management Strategy
In addition to the land required for residue and refinery operations, Alcoa has purchased additional land under Alcoa's Land Management Strategy. Alcoa implemented a land management strategy in 2001-02 around the Wagerup Refinery which enabled people living in the immediate vicinity who felt impacted by the operations to sell property to Alcoa.

The Strategy comprised of two areas:
- Area A – immediately surrounding the refinery; and
- Area B – the townships of Yarloop and Hamel.

The land management strategy is implemented by Alcoa and has no formal status in planning schemes or legislation. The characteristics of Area A and B are outlined below, and the location of each is shown in Figure 6-4.

Area A
- Area A was delineated to the north and south based on the 35dB(A) noise contour.
• It allows for future expansion of Alcoa’s bauxite residue area to the west (The actual footprint of the refinery will stay the same, even if production is lifted in the future).
• Alcoa does not on-sell properties purchased in Area A.
• Area A properties (northern Yarloop townsite) are rented out by Alcoa, sometimes to the previous owners.

Area B
• Alcoa’s land management strategy was extended to the townships of Yarloop and Hamel to enable people who owned property before 1 January 2002, to sell that property to Alcoa at unaffected market value. This area is known locally as Area B.
• No environmental factors influenced Area B boundaries. It was established to help ensure township viability into the future.
• Properties in Area B are re-sold to maintain property values and support the viability of the town sites.

• Alcoa will only purchase a property once.
• The Area B offer expired on December 31, 2011. Alcoa will now only consider purchasing properties in this area after the property owners have demonstrated they have not been able to sell their property on the open market.

6.6.2 Supplementary Property Purchase Program
The Supplementary Property Purchase Program (SPPP) was established by the WA Government as part of the environmental approval, granted in September 2006, for Alcoa’s proposed Wagerup Refinery expansion. The SPPP was managed by an administrator appointed by the WA Government.

The SPPP enabled eligible property owners, outside the existing Areas A and B; in the localities of Hamel, Wagerup, Yarloop and Cockernup, to sell their property to Alcoa should they wish to do so.

The two key principles underpinned the SPPP, as set out in a Deed of Undertaking Between the WA Government and Alcoa. These principles were that the SPPP:
• Should cause minimum impact on the local property market, disruption to the local community or impact on the Wagerup Refinery; and
• Should not create a financial incentive for people to sell to Alcoa rather than through the established property market.

While Alcoa supported the SPPP, extensive research has shown that the Wagerup Refinery is safe for the community and employees and there is no need for people to move away from the area.

Figure 6-4: Map of Areas A and B in Alcoa’s Land Management Strategy.
6.7 Local, Regional and State Planning Policies and Visions

The development of the LTRMS, and final land use planning objectives, were informed by presentations to the SRG on current planning policies and visions for the region by the Department of Planning and Shire of Harvey. The Shire of Waroona were unavailable to present to the SRG.

Together with a commitment to best practice environmental controls, compatible land use planning is considered necessary to prevent conflict from urban encroachment on industrial operations. Compatible development does not seek to quarantine land from development, but to ensure the development is appropriate in order to protect the interests of potential neighbours, Alcoa’s employees and shareholders, local contractors and businesses, and local and state government agencies who field and investigate complaints.

The sections below describe the various strategic plans that provide the planning framework for local area.

6.7.1 Directions 2031 and Beyond and the Outer Metropolitan Perth and Peel Sub-Regional Strategy

In 2010, the Western Australian Planning Commission (WAPC) released the Directions 2031 and Beyond final report. This report is the highest level strategic plan and spatial framework for the metropolitan Perth and Peel region. It establishes a vision for future growth and guides future urban growth, and seeks to address population growth scenarios and land use patterns for the Perth and Peel regions (WAPC, 2010).

Due to the complexity of the strategic planning, sub-regional strategies are required to provide guidance at a local level. The sub-regional strategies addresses issues that extend beyond local government boundaries and that require a regional response, and common issues such as provision of housing choice and affordability (WAPC, 2010).

The Outer Metropolitan Perth and Peel Sub-Regional Strategy identifies the Wagerup refinery and residue area as a strategic industrial centre and a critical component in the future development of the Peel sub-region.

6.7.2 Peel Region Scheme

The Peel Region Scheme is a large town planning scheme which guides land use in the Peel Region, which includes the local government boundaries of the City of Mandurah and the Shires of Murray and Waroona. The Peel Regional Scheme defines the future use of land by dividing it into broad zones and regions. The local government town planning schemes provide the detailed plans for their respective parts of the region. The Wagerup refinery and residue area are located on industrial zoned land within the Peel Region Scheme (Department of Planning, 2012)

6.7.3 Local Planning Schemes

Town of Waroona Town Planning Scheme

The Town of Waroona Town Planning Scheme No 7 establishes Industrial zoning for the Wagerup refinery and residue area. As part of the future residue development strategy, Alcoa has identified the need to extend the residue area, and a rezoning process will be required to extend the industrial zoning boundary to facilitate this. See Section 8.8.2 for further details.

The area to the west of the existing residue area is currently zoned Rural 1 – General Farming, and the areas to the north and south of the existing residue area are zoned Rural 2 – Irrigated Agriculture.

Town of Harvey Town Planning Scheme

The Shire of Harvey Town Planning Scheme No 1 establishes General Farming zoned land in the area adjacent to the Shire of Harvey’s northern boundary, directly south of the Wagerup refinery and residue area. The area to the west of the towns of Wagerup, Yarloop and Cookernup are zoned for Intensive Farming.
Environmental issues at the residue facilities are managed through a comprehensive environmental management system (EMS). The EMS was initially developed for the residue area in recognition of the importance of a rigorous, documented process of environmental management and certified to ISO 14001 in December 1999. Subsequently, the EMS was extended to the remainder of the Wagerup Refinery, which gained ISO 14001 certification in February 2001. The key elements of the system are:

- an environmental policy;
- processes to identify environmental legislation;
- a risk based process for identifying key environmental aspects and potential impacts;
- detailed procedures for managing key system elements including, but not limited to, environmental training, incident reporting and internal auditing;
- detailed procedures for the control of operations to minimise potential impacts;
- extensive process emission and environmental impact monitoring; and
- an annual process of reviewing key environmental issues and developing environmental management plans for each operating area.

The remainder of this section describes the key environmental issues for the residue area. These have been identified through risk assessment processes and also reflect issues of concern to stakeholders, as identified by the Wagerup LTRMS SRG. The SRG members were provided with detailed information on the current issues and management strategies for the residue areas to assist them to provide informed input to the review of the LTRMS.

Dust generated from the residue area mostly consists of fine clay particles and some sodium carbonate crystals precipitated on the surface of residue as entrained moisture evaporates. Residue dust is slightly alkaline and could be an irritant if high enough concentrations occurred – however extensive monitoring data shows this is very unlikely as the level of dust emitted from the residue area is well below the level likely to cause any health impacts. Dust impacts from the residue areas are predominantly due to wind erosion, rather than mechanical sources (GHD, 2008). Wind speeds in excess of 6.5 m/s (23 km/h) can pick up and transport fine residue and carbonate particles from dry residue surfaces. The distance over which these particles are transported depends on a variety of conditions.
The months from October to April are considered to be the time of the year when the risk of airborne dust generation is potentially greatest. In summer, the predominant winds are moderate to strong east-southeasterly winds and moderate southwesterly winds. Strong and gusty southwesterly winds often develop around midday with the onset of the sea breeze which eases in the late evening. The speed of these winds together with the higher ambient temperatures over summer, and therefore faster mud drying rates, require careful control mechanisms to be in place to prevent dust being released. In response to learnings from past dust management performance, Alcoa has recently improved its dust management procedures by applying the stringent summer dust management protocols to the entire year.

Alcoa’s Wagerup Refinery received a total of eight complaints from community members relating to dust from the residue areas between 2007 and 2011. Dust management from the residue area was a key issue discussed by the Wagerup LTRMS SRG.

7.2.2 Current Management Strategies

The nature of the residue and the deposition and drying process results in a range of differing materials and surface textures that have the potential to generate dust under windy conditions. As such the dust management systems in place are complex and consist of a range of both proactive and reactive strategies. A significant effort in planning, implementation and monitoring of the measures is undertaken to ensure best possible control of dust generated from the embankments, stockpiles, roads, verges and drains.

Long-term, mid-term and day to day controls are in place to manage residue dust at Wagerup, and an overview of each follows.

**Long-Term Controls (annual)**

During each winter, dust control measures for the coming year are planned. These measures aim to ensure that:

- activities with a higher risk of dust generation, such as sand stockpiling and sand construction activities, are performed in winter months, wherever possible;
- dust control mechanisms are in place for any newly constructed or exposed embankments;
- new or exposed internal embankments likely to remain in place undisturbed for an extended period are planted with native vegetation or grasses during winter to allow them to establish an effective long-term dust control cover;
- embankments or areas that are not required in the shorter term are covered with crushed rock aggregate or woodchips (mulch); and
- the frequency for application of dust suppressants to exposed surfaces, such as roadways, is specified.

**Mid-Term Controls (weekly)**

Dust management activities are tracked at weekly review meetings, which include the personnel involved in dust control and operational activities that could generate dust. Regular inspections and surveys are carried out to check the effectiveness of dust controls and identify areas needing attention. These reviews monitor the activities and conditions that could lead to dust events.

A specialist consulting company supplies dust suppressants to exposed surfaces, such as roadways. The sprinkler system is operated in response to daily weather forecasts and residue area conditions and continuous dust monitors around the residue area. Internal alarms are triggered in the event of dust levels above internal targets. Sprinklers are operated in response to alarms and proactively to wet down areas prior to forecast weather conditions.

**Sprinkler System Upgrade**

The original sprinkler designs used at the Wagerup residue area were based on 60 meters by 90 meters sprinkler spacing, which aimed to provide effective dust control for the major prevailing winds. As part of Alcoa’s commitment to continuous improvement, a study was completed on the effectiveness of the residue sprinkler systems. As a result of the study, the design standard was changed to reduce the sprinkler spacing to 60 meters by 60 meters to address coverage issues under higher wind speeds and all wind conditions. All RSAs constructed at Wagerup since 2000 meet the current design standard.
During 2004 Alcoa performed internal reviews and commissioned independent external advice on its sprinkler design and operation before deciding to retrofit the new sprinkler spacing to residue areas built before 2000. The sprinkler upgrade project was completed at Wagerup in 2009. Figure 7-1 shows the impact of the change in sprinkler design.

**Turning Over Mud**

Wide-track bulldozers are utilised to turn over the top 0.5-1 meters of residue. This process reduces exposure of dry residue which is prone to dusting, while increasing overall drying rates within the stack. Since 2005, amphirols have been put into use at Wagerup as well as bulldozers. Amphirols can access the residue surfaces earlier in the drying cycle.

**Aggregate**

Crushed rock aggregate has been used for some time as an effective dust suppressant on flat sand areas that are not scheduled for work in the short-term.

**Mulch**

Since 2005, mulch is used more extensively now than just on flat surfaces. Its use has been extended to internal batters, low traffic roads, beached areas and sand stockpiles as it is more economical and can be applied to a broader range of surfaces than aggregate. The mulch is sourced from Alcoa’s mining operations and other local sources, and has been found to also assist in the establishment of residue embankment rehabilitation.

**Dust Monitoring Network**

Particles exist in the atmosphere from a range of sources, both natural and man-made. Alcoa’s dust monitoring program determines the contribution of dust particles from residue areas to the local surrounding environment.

Dust particles occur in different sizes, and various size fractions are important for different reasons. Larger size fractions typically present more of an amenity impact, whereas smaller size fractions can be inhaled. The terminology for dust size fractions monitored historically at Wagerup is as follows:

- **TSP (Total Suspended Particulate Matter)** – particles with an aerodynamic diameter <50 μm; and
- **PM$_{10}$** (particulate matter <10 μm) – particles with an aerodynamic diameter <10 μm.

TSP is regularly monitored around the refinery and residue area. PM$_{10}$ was monitored at all of Alcoa’s WA residue areas in 2007 to collect data for a residue dust health risk assessment (HRA). Results of the HRA are discussed in Section 7.5.

Alcoa’s Wagerup Refinery DEC licence requires Alcoa to operate an ambient dust monitoring program. Alcoa operates five licensed Hi Volume Sampler (HiVol) dust monitors which produce daily averaged dust concentrations. In addition to these licensed monitors, Alcoa also operates three non-licensed Hi-Vol monitors and five continuous Tapered Element Oscillating Microbalance (TEOM) dust monitors for internal residue dust management purposes. The continuous TEOM monitors produce digital averaged six minute dust concentrations and are linked to process control computers. Figure 7-2 shows the current residue dust monitoring network.

![Figure 7-1: Old and new sprinkler designs.](image-url)
This system is programmed to activate an alarm system to alert the operators and area supervisors to the recorded dust levels so they can enact targeted control measures quickly.

**Ambient Dust Standards**

Generally speaking, when people experience dust, they cannot differentiate with confidence the source of the dust unless there is a visible pathway. Similarly, ambient dust concentration measurements are do not differentiate the source (GHD, 2009).

Ambient dust monitoring at the Wagerup residue area is carried out in accordance with the DEC licence conditions. Currently these conditions specify that Alcoa must report to the DEC any daily dust licence limit exceedance (260 μg/m³ 24 hour average, background corrected) or annual dust licence limit exceedance (200 μg/m³ on more than 18 days, 24 hour average, background corrected) as determined by monitoring at licensed high volume samplers. Any Hi-Vol dust monitor level which exceeds Alcoa’s internal standard of 90 μg/m³ is investigated to determine the root cause(s).

The non-licensed real time TEOM monitors have internal targets which activate the Alcoa control room alarm system if they are exceeded. The purpose of the more stringent internal standards and the real time monitoring system is to provide early warning to Alcoa of potential dust issues and to ensure that Alcoa achieves a higher level of dust performance than the acceptable licence limit.

**Dust Performance**

Each dust target exceedance at a licensed monitor is reported to the DEC as soon as practicable after receiving the confirmed dust measurement. Alcoa completes an investigation into the meteorological conditions, potential sources and dust control measures during the sample period. A report of the findings is submitted to the DEC within seven working days after receiving the confirmed dust measurement. All licence dust monitoring data is summarised and presented in annual environment reports to the DEC.

In the period 2007-11, there was only one exceedance of the dust licence limit. The elevated dust reading was recorded at the Residue West monitor and was caused by Alcoa contractors spreading mulch around the monitor to minimise dust generation from cattle activity and as such was not contributed to by refinery operations.
Alcoa's Response
Alcoa accepts and agrees with this principle. As part of the environmental management system, Alcoa regularly reviews its dust management processes and practices with the objective of continuously improving dust containment at the residue areas. Since 2007, Alcoa made further significant improvements to its dust management processes and Alcoa will continue to monitor the effectiveness of these changes and make further improvements as necessary.

Guiding Principle: Communication of Dust Improvements
Communicate dust management improvements and results from dust investigations to the CCN, SRG and surrounding community members in a timely manner.

Alcoa's Response
Alcoa will communicate dust management improvements and relevant learnings from dust investigations at least annually to the CCN and to surrounding community members.

7.3 Odour & VOCs

7.3.1 Background
Odorous emissions from alumina refineries are caused by the breakdown of organic material contained in the bauxite, additives to the liquor stream and by-products of fuel combustion processes. Odour comes from a range of compounds, including some volatile organic compounds (VOCs), ammonia sources and others, and is an amenity concern for the local community.

7.3.2 Odour & VOC Monitoring Results
In 2004 odour and VOC emissions from various residue sources were measured directly for the first time at Alcoa’s Wagerup Refinery. The emissions monitoring program targeted VOCs, carbonyls and odour and used a flux chamber monitoring technique. The results of this monitoring enabled an understanding of the relative significance of diffuse emission sources within the residue area. Test results indicated that odour emission rates are a function of surface moisture levels, temperature and liquor concentrations. Consequently the major sources of odour and VOCs from residue facilities were those receiving liquor at higher temperatures.

The study also confirmed that a number of environmental factors affected the release of odour and VOCs from sources in the residue area. The rate of release of odour and VOCs from residue sources is affected by surrounding air temperature, with lower release rates at night than during the day, and lower rates in winter than in summer. The release rate is also affected by local wind speeds, with lower release rates at lower wind speeds.

7.3.3 Reduction Strategies
Odour and VOC emissions from the surface of the residue area are a function of the temperature and odour/VOC concentration at the residue surface. The higher the temperature and compound concentration of the liquor surface, the higher is the emission of odour/VOC to air. The main source of VOC input into the residue area comes from refinery cooling water. In most cases, cooling water that makes contact with refinery liquor streams will condense and absorb VOCs from the liquor.

The 2004 odour study indicated that the higher sources of odour for Wagerup included the cooling pond, the RSA2 wet storage area (which has now been converted to dry stacking), and the super-thickener.
The study also confirmed that a number of environmental factors affect the release of odour and VOCs from sources in the residue area. The rate of release of odour and VOCs is affected by the surrounding air temperature and local wind speeds. Lower odour and VOC release rates occur at night than during the day, and in winter than in summer as the air temperature is cooler. Lower odour and VOC release rates also occur at lower wind speeds.

This 2004 study provided an indication of the proportion of Wagerup’s odour and VOC emissions that originate from the residue area. The study estimated that residue contributed approximately 50% of the total odour emissions from Wagerup Refinery.

**7.3.4 Impact of Expanded Residue Footprint on Odour and VOC Emissions**

Any expansion of drying areas at current refinery production rates would have a minimal impact on odour and VOC emissions from residue given the amount of fresh mud being deposited remains relatively stable. Residue drying areas have a minimal contribution to odour and VOC emissions from the residue areas. The construction of RSAB is estimated to have increased the total odour emissions from the residue area by less than 1%.

Odour and VOC emissions are more impacted by the temperature of liquor streams and the concentrations of VOCs in the liquor streams. Liquor reporting to residue comes from a number of different sources in the refinery with differing temperatures and concentrations of VOCs.

**7.3.5 Odour Guiding Principles and Alcoa’s Commitments**

In response to the information provided, the Wagerup LTRMS SRG developed two guiding principles relating to odour and VOCs. These are presented below, together with Alcoa’s response.

**Guiding Principle: Odour Characteristics**

Alcoa to identify odour characteristics and implement mitigation strategies to reduce odour and VOC emissions.

**Alcoa’s Response**

The Alumina Industry Air Emission Forum (AIAEF) is currently considering a proposal to conduct research into the odorants that create the “wet cement” odour associated with the Bayer Process (the process Alcoa utilises in its refineries to produce alumina). Alcoa is a member of the AIAEF and supports this research proposal.

**Guiding Principle: Research Outcome Communication**

Communicate outcomes of research into odour and VOC emissions, and provide information on odour and VOC emission mitigation strategies to the community via avenues such as the CCN.

**Alcoa’s Response**

Alcoa accepts and agrees with this principle. Alcoa will communicate information and outcomes of research on odour and VOC emissions subject to commercial confidentiality considerations.

**7.4 Radiation**

**7.4.1 Background**

Radiation is widespread in the environment. It comes from sources outside the earth’s atmosphere, rocks and soils, and from building materials such as bricks, mortar, concrete and tiles. It also comes from the food and drinks we consume, and from man-made sources such as dental and chest X-rays.

Background radioactivity levels are quite variable. Levels associated with the rocks and soils of the Darling Range are usually higher than those found on the coastal plain. Darling Range soils, including the bauxite deposits, contain small amounts of thorium and uranium. The extraction of around 30% of the bauxite as alumina results in a proportional increase in the concentration of these elements per volume of residue. The dry stacked residue mud itself therefore exhibits levels of gamma radiation marginally above background levels found in Darling Range soils (O’Connor, 1989). It should be noted that no radiation is added through the refining process.

**7.4.2 Radiation Monitoring Results**

Alcoa of Australia has been studying the radiological aspects of its bauxite processing operations in Western Australia for more than 20 years. The various studies have considered the following major issues:

- whether the low levels of natural radioactivity in feedstock, intermediate and final materials (products and residue) pose discernible problems from a radiation health perspective and, if so, what actions might be required for the operations to be managed in a responsible and acceptable manner;
- whether the processing of bauxite materials poses discernible radiological hazards for the workforce and for members of the general public, including impacts from the RSAs prior to and following rehabilitation; and
- whether potential end-uses of the residue materials are radiologically acceptable.

This has involved comprehensive monitoring of air, water and soil, and has included both fixed location (area) monitoring and personal sampling of members of the workforce who spend most of their time working on the residue surface. Results are documented in scientific reports, and have been provided to relevant government agencies. Sampling equipment, methods and techniques have been endorsed by relevant statutory bodies such as the Radiological Council of WA. The accepted international and national radiation limit for occupational exposure is 20 mSv (millisieverts) averaged over a period of five consecutive calendar years. The accepted international and national radiation limit for the general public is 1 mSv per annum (above background).
personal exposure readings for the Alcoa residue workforce are within the limit set for the general public. That is, readings have been more than 20 times less than the limit allowed for workers (Alcoa, 2004).

Studies have also found that in the unlikely event that a member of the public would spend 24 hours per day, 365 days per year at the edge of the RSA, then the exposure received would be approximately 0.12 mSv above local background. This level is well within the limits that are applied to the general public and well below the background levels experienced in many residential areas on the Darling Scarp (Alcoa, 2004).

Therefore, while bauxite and bauxite residue contain traces of radioactive materials, exposures associated with this have been comprehensively studied and all levels have been demonstrated to be well within acceptable limits prescribed for both the workforce and the public.

7.4.3 Changes in Radiation Guidelines and Management Since 2005

Recently the International Atomic Energy Agency developed guidelines on the management of materials that contain naturally occurring radionuclides (NORMS). Australia has adopted these guidelines, which require materials with radiation levels above 1 Becquerel per gram (Bq/g) to implement specific monitoring and reporting, however Western Australia has yet to implement these guidelines.

Once the guidelines have been implemented in Western Australia, Alcoa will be able to request exemption to the reporting requirements if it can demonstrate exposure levels to radiation for employees are less than 1 mS/year (public exposure).

During 2008-09 Alcoa performed additional NORM monitoring focused at mining and residue to provide information required to support our exemption application. The results, as shown in Table 7-1, are well within the public exposure standard.

<table>
<thead>
<tr>
<th>Monitor</th>
<th>Gamma</th>
<th>Radon Progeny</th>
<th>Total Dose (Ann)</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residue Operator</td>
<td>&lt;0.12</td>
<td>&lt;0.12</td>
<td>&lt;0.24</td>
<td>1</td>
</tr>
<tr>
<td>Residue Maintainer</td>
<td>0.16</td>
<td>0.42</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>Dozer Driver</td>
<td>0.12</td>
<td>&lt;0.12</td>
<td>&lt;0.24</td>
<td></td>
</tr>
<tr>
<td>Residue Super Thickeness</td>
<td>&lt;0.12</td>
<td>&lt;0.11</td>
<td>&lt;0.43</td>
<td></td>
</tr>
<tr>
<td>RSA Central</td>
<td>&lt;0.12</td>
<td>&lt;0.10</td>
<td>&lt;0.42</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7-1: 2008-09 NORM monitoring results for residue personnel.

7.4.4 Current Management Strategies

Although radiation levels are low enough that no specific management strategies are required to meet accepted exposure standards, Alcoa uses the three principles of radiation protection to minimise exposure of employees to radiation. These are:

- time: radiation dose is directly proportional to duration of exposure;
- distance: the distance of exposure determines the dose rate according to the inverse square law; and
- shielding: the effectiveness of a material for radiation shielding is determined by its density and atomic number.

Personal exposure monitoring is carried out to determine the exposure of employees to radiation and to ensure these levels are kept within accepted health standards.

7.4.5 Impact of Expanded Residue Footprint on Radiation Emissions

The nature of radiation exposure means that changes to the height or footprint of the residue area will not increase the risk of radiation to the public. Immediately adjacent to the boundary of an expanded residue area the levels of radiation exposure will remain well within exposure standards and less than natural background levels in many local residential areas.

7.4.6 Radiation Guiding Principles and Alcoa’s Commitments

In response to the information provided, the Wagerup LTRMS SRG determined that a guiding principle related to radiation was not required.

7.5 Residue Emissions and Health

7.5.1 Background

Air emissions from residue that have the potential to impact on community health include dust from RSAs, embankments and other sources as detailed in Section 7.2, and chemical compounds emitted from wet storage areas, and other sources as detailed in Section 7.3.

The potential health impacts of dust are related to the size of the dust particles, their chemical composition and most importantly their concentration in the air near residential areas. Very small dust particles (PM$_{10}$ and PM$_{2.5}$) can be breathed into the lungs and in major cities have been associated with heart and lung disease. Additionally some chemicals in residue dust and vapour, such as formaldehyde and acetaldehyde, and the alkalinity of the dust, are potentially irritants if high enough concentrations occur.

Some compounds such as acetaldehyde have low odour thresholds and can be detected at concentrations which are too low to cause health effects. Similarly larger dust particles can cause an amenity impact even though they do not constitute a potential health impact.
In 2004 Alcoa voluntarily committed to a major research program aimed at further improving its understanding of the contribution made to regional dust by its alumina refineries in WA. An independent Health Risk Assessment (HRA) was then performed to investigate the health risks associated with residue dust. A summary of the results is presented below.

7.5.2 Residue Dust Study
It was decided to focus the research at one refinery, Pinjarra, with input from other sites as necessary to validate the general conclusions.

Monitoring ran over eighteen months from mid 2005 to December 2006, capturing two winter/spring/summer periods and one autumn. It has since been shown that 2006 was an atypical year for dust with stronger winds than average, combined with significant construction activity, problems with parts of the residue area sprinkler control system and other factors leading to higher dust levels. The dust study results can therefore be regarded as conservative.

The program was run for Alcoa by experienced accredited consultants. Three companies were involved, each being highly regarded within their area of expertise:
- Ecowise Pty Ltd – dust sampling and sample analysis;
- Air Assessments Ltd – data evaluation, meteorological and statistical analysis; and
- Environ Ltd – health risk assessment.

All methods, analysis and calculations were performed to Australian Standards and NATA testing accreditation performance requirements. Samples collected to analyse the composition of the dust were performed using:
- High Volume Air Samplers – 7 day and selected 24-hour samples;
- Low Volume Air Samplers – 7 day and selected 24-hour samples;
- Deposition – monthly;
- Grab Samples from the RSAs and surrounding areas; and
- Water – following rain.

The key conclusions from the Residue Dust Study were as follows:
- There is a very low PM$_{2.5}$ fraction in RSA dust. PM$_{10}$ emissions from the residue areas are well below advisory criteria and not an issue of any significance;
- Use of up-wind and down-wind TEOMs worked well & indicated that the RSA can contribute the majority of TSP and PM$_{10}$ during 1-hour and 24-hour dust events, but is a much smaller contribution to annual average concentrations and to PM$_{2.5}$; and
- The best individual chemical marker for residue dust appears to be the trace element thorium, which though present at very low concentrations, is relatively easy to analyse for.

A specialist radiation consultant from Curtin University was invited to review the dust study data to determine if the levels of thorium found were of any concern in terms of radiation exposure. He concluded that the level of radiation expected for such low concentrations of thorium in dust (as found in the Alcoa dust study) was many times lower than the public exposure limit (1 mSv per annum above background), and well below background radiation levels typically expected.

7.5.3 Health Risk Assessment Results
A Health Risk Assessment (HRA) is a risk assessment process that compares the ground level concentrations (GLCs) of compounds with their health guidelines set by national and international health agencies. The GLCs are predicted by air dispersion computer modelling. The HRA considers the:
- risk of short-term (acute) health effects in relation to short-term exposures (1-hour & 24-hour averages);
- risk of long-term (chronic) health effects in relation to long-term exposures (annual averages); and
- incremental risk of cancer in relation to long-term exposures (annual averages over 70 years).

To increase confidence in the HRA for dust it contained several layers of conservatism. It assumed sources were emitting at peak emission rates simultaneously, and assumed the risks of emissions were additive in nature. The model took into account local meteorological conditions.

The HRA considered inhalation exposure to the following substances/elements:
- PM$_{10}$ (Particulate Matter < 10 μm diameter); and
- The metals arsenic, selenium, manganese, cadmium, nickel, mercury, chromium, beryllium, lead and vanadium.

Other metals analysed but for which health guidelines are not available were not included in the HRA. The full details of the HRA (Environ, 2008) can be found on Alcoa’s website (http://www.alcoa.com.au/healthandwellbeing).

Based upon the results of the HRA it can be concluded that:
- the potential for emissions from the baseline or upgraded RSA to cause acute health effects presents no cause for concern;
- the acute Hazard Index (HI) is primarily driven by exposure to PM$_{10}$ not to individual metals in RSA dust;
7.6 Waste

7.6.1 Background
Waste generated at the Wagerup Refinery can be broadly categorised as either non-process waste or process waste.

Non-process waste includes:
- Laboratory wastes;
- Office wastes;
- Sewage;
- Garden wastes;
- Food wastes; and
- Wood wastes.

Process wastes from the refinery include any waste that is derived from an ingredient of the Bayer process. Process wastes include the following:
- Scale (any solid material from process circuits or tanks that contains caustic);
- Bauxite residue;
- Waste alumina and hydrate; and
- Oxalate.

Oxalate originates from broken down organic material (plant and animal matter as humus) in the bauxite. Within the refinery process this organic matter forms sodium oxalate. Over time, the level of oxalate builds up in the recycled caustic liquor circuit, which negatively impacts upon the alumina product quality and the production yield of alumina. Consequently, as part of the alumina refining process, oxalate needs to be removed from the liquor. Although oxalate is a compound commonly found in the environment and is not intrinsically harmful, the oxalate extracted from the refinery process has a high caustic concentration and hence requires appropriate handling, storage and treatment.

7.6.2 Current & Future Management Strategies

Non-Process Waste
The Wagerup residue area operates a licensed Class II landfill area which takes wastes generated from the refinery and residue area. The Class II landfill accepts certain non-recyclable non-process wastes.

On site waste disposal reduces pressure on municipal landfills. The overall volume of waste disposed to the landfill is less than 1% of total residue produced per annum. Alcoa has a significant ongoing focus on reducing waste to landfill. New and improved recycling programs have made advances in the area of waste recycling and minimisation.

Alcoa’s waste management program includes the recycling of waste oil, scrap metal, gloves, fluorescent lights, automobile batteries, liquid waste, electronic waste, cardboard, tree/garden clippings, drums, food waste, cooking oil and printer/toner cartridges. Details of waste materials are recorded in a comprehensive database. Recyclable material is classified and separated prior to removal from site and the remnants are disposed to the Class II landfill area within the residue area.

Process Waste
A separate tip face, which does not form part of the Class II landfill, accepts solid process waste such as scale. Bauxite residue is processed and dried in one of the residue storage areas. While Alcoa’s corporate goal is to reduce landfilled waste, Alcoa also recognises that there are opportunities to track and reduce process waste (e.g. through residue reuse). The reuse of bauxite residue is discussed in Section 4.6.

Oxalate
In the past, oxalate has been managed at the Wagerup Refinery using several techniques:
- Storage in purpose built oxalate storage ponds;
- Oxidised using an Oxalate Kiln; and
- Reacted with lime (to form calcium oxalate) and stored within residue mud.

Wagerup Refinery has recently refurbished its oxalate kiln. The kiln was recommissioned in mid 2012. Testing is underway to determine the capacity of the recommissioned kiln, however it is not expected to have the capacity to treat all of the oxalate produced. Alcoa is now assessing the oxalate recovery and
7.6.3 Waste Guiding Principles

In response to the information provided, the Wagerup LTRMS SRG developed one guiding principle relating to waste. This is presented below, together with Alcoa’s response.

Guiding Principle

Alcoa to set the maximum achievable target for oxalate recovery within 12 months of the implementation of the Bio-oxalate removal plant, in consultation with the local community.

Alcoa to develop and implement a program to achieve this target, with timelines communicated to the community. This target will be based on current storage levels and removal capacity.

Alcoa’s Response

Alcoa is currently assessing oxalate recovery and destruction capability at Wagerup. Once the capability is determined, Alcoa will consult with the local community prior to establishing the oxalate recovery target, and implement a program to achieve this target.

7.7 Water Use

7.7.1 Background

The Wagerup Refinery operates an efficient closed water circuit, which is supplemented for water losses.

Water sources for the refinery include:

- Rainwater that falls on the refinery and residue areas.
- Surface water sourced under licences from the Department of Water.
- Licensed ground water recovery bores on site and water brought in with bauxite (% moisture).

Water sources for the refinery include rainwater that falls on the refinery and residue areas; surface water sourced under licences from the Department of Water; licensed ground water recovery bores on site and water brought in with bauxite (% moisture).

Refinery. The plant was commissioned in 2009 and is the first plant of its kind in the world. Bio-removal is a biological process that breaks down the sodium oxalate and produces significantly less carbon dioxide than burning.

Alcoa has already constructed and commissioned an Oxalate Bio-removal plant at Kwinana and is the first plant of its kind in the world. Bio-removal is a biological process that breaks down the sodium oxalate and produces significantly less carbon dioxide than burning.

It is currently anticipated that part of Wagerup’s additional oxalate destruction program may include the construction of an Oxalate Bio-removal plant. Alcoa has already constructed and commissioned an Oxalate Bio-removal plant at Kwinana in 2009 and is the first plant of its kind in the world. Bio-removal is a biological process that breaks down the sodium oxalate and produces significantly less carbon dioxide than burning.

Wagerup Refinery is located within the Harvey River Basin and is licensed by the Department of Water (DoW) to divert and abstract surface water. Surface water is taken from the following three licensed sources:

- Yalup Catchment, via the Upper Yalup Dam. This water is used as a source of potable water to the Refinery and for process make-up water as required;
- Black Tom Brook Catchment. This water is primarily used for dust control on the residue area and as process make-up water; and
- Harvey River, via the Harvey River Pumpback System. This water is primarily used for dust control on the residue area.

Wagerup Refinery is also licensed to abstract groundwater from depressurising bores at the residue area to ensure groundwater levels remain below the base of the RSAs, and from two groundwater recovery bores in the refinery area.

The RSAs have base drainage systems that collect residue leachate and rainfall infiltration. The majority of rainfall runoff from the refinery, RSAs and process water ponds is transferred to the Cooling Pond or Runoff Water Storage Pond during winter and then used as make-up water for the refinery during summer.

7.7.2 Current Management Strategies

The largest use of water at the residue area is the operation of the dust control sprinklers. Water use for the sprinkler system has increased significantly over the last few years, in response to more conservative dust management practices and the sprinkler upgrade. While this has resulted in a significant improvement in dust management, the current dust management focus is now on maintaining dust performance while optimising water use.

Alcoa has implemented a number of water efficiency improvements for the residue areas in the past couple of years including:

- New sprinkler spacing to improve water use efficiency;
- Improved sprinkler use management processes which has improved overall water use; and
- Increased use of mulch and aggregates for dust control.
Alcoa is undertaking ongoing research into alternative water sources and water conservation initiatives, including investigating the effectiveness of a range of dust suppressant products.

**Impact of Expanded Residue Area**

The amount of water required for dust suppression is related to the open drying area, and the open drying area is related to the refinery production rate. Therefore, any major increase in production will require a larger volume of water for residue dust suppression. Over time, with a stable production rate, the amount of drying area will oscillate around a relatively constant area (new areas will increase the open area but will then be consumed over time until new areas are required to offset the losses) and water use will therefore remain relatively constant.

**Guiding Principles and Alcoa’s Commitments**

In response to the information provided, the Wagerup LTRMS SRG developed one guiding principle relating to water use. This is presented below, together with Alcoa’s response.

**Guiding Principle**

Alcoa to continue to focus on water efficiency by maximising water conservation and the use of recycled and fit for purpose water.

**Alcoa’s Response**

Alcoa accepts and agrees with this principle.

**7.8 Surface Water**

**7.8.1 Background**

The Wagerup Refinery operates a closed water circuit, meaning that the refinery does not discharge any process water from the site. Fresh water only leaves the refinery property if the fresh water storage dams overflow.

Stormwater that runs off the residue or refinery process areas is characteristically alkaline. This renders the water unsuitable for direct discharge to the environment. Therefore all rainfall runoff from the refinery and residue process areas is collected and stored in lined ponds within the residue area for recycling via the refinery process as make-up water.

Three significant water transfer systems (drains/pipes) cross Alcoa’s Wagerup landholdings:

- South Samson Drain flows from the north eastern corner of the residue area to the western edge of Alcoa’s property where it enters the Harvey River.
- The South Samson Diversion Drain was installed by Alcoa as an alternate route to allow water from
Black Tom Brook to be harvested, and to allow water from the North Yalup Brook to enter the Harvey River. The South Samson Diversion Drain directs water from Black Tom Brook into Detention Pond 1, as well as providing a flow path for water purchased from Harvey Water to be collected via the South Samson Drain. Overflows from Detention Pond 1 are diverted around the southern side of the residue area.

- Overflows from the Pipe Head Dam (diversion point for North Yalup catchment to the Upper Yalup Dam) flows along the Yalup Brook to the Diversion Drain, traversing the Alcoa property from east to west.

During the winter months, the majority of local stormwater from Alcoa's property not collected within the refinery and residue areas is carried away via the above systems.

### 7.8.2 Current Management Strategies

Alcoa manages the risk of surface water contamination from the residue facilities by implementing practical measures to ensure no contaminated stormwater is released from the residue area.

The RSAs have base drainage systems that collect residue leachate and rainfall infiltration. This underdrainage and surface water runoff is transferred to a Runoff Collection Pond (ROCP) and then pumped to the Run Off Water Storage (ROWS) Pond or the Cooling Pond.

Under normal rainfall conditions water collected on the surface of the residue area is allowed to drain freely to a ROCP. Under severe storm conditions water may need to be retained in the RSAs by closing the decant weirs to prevent an unmanageable amount of water reporting to the ROCPS. Operational guidelines stipulate that storm surge capacity must be maintained within the residue area to capture 100% of any storm event, based on a 1:100 year 72 hour storm and a 10 day post storm event recovery period.

The ROWS Pond has three main functions. The primary function of the ROWS pond is to collect surface runoff water and provide bulk storage of water for process requirements. The second function of the ROWS Pond water is to provide make up water to the Cooling Pond. The Cooling Pond make up will normally be required at the end of summer when the Cooling Pond volume is at its lowest level. The third function of the ROWS pond is to accommodate surges in the total water volume in the residue area as evaporation and rainfall vary throughout the year.

The overall stability of the residue drying facilities has been designed in accordance with international standards to accommodate both static and earthquake loadings (Dames and Moore, 1991). While failure of outer stack slopes might cause short-term operational problems (such as ruptured pipelines) it should not result in any flow of residue into the surrounding environment. The structural integrity of water storage ponds and RSA embankments are inspected annually by an independent consultant.

In response to the catastrophic loss of residue containment in Hungary in 2010 at Magyar Aluminium's Ažka alumina refinery, Alcoa is undertaking a review of its residue design standards and management performance criteria to ensure adequate processes are in place to ensure stability is addressed as an ongoing priority between annual reviews.

### 7.8.3 Surface Water Monitoring

An extensive network of surface water monitoring points is established upstream and downstream of Wagerup Refinery’s operating areas to measure any long-term water quality changes associated with the refinery and residue operations. The monitoring program also provides data to ensure that abstraction levels do not exceed the water requirements of the local environment. Figure 7-3 shows the location of the 23 surface water monitoring sites.

A comprehensive monitoring program has been developed which details the frequency of monitoring, parameters to be analysed, and procedures to use for each monitoring location. Water quality monitoring includes measurements of pH, electrical conductivity (EC) and alkalinity and trace elements including aluminium, arsenic, mercury, selenium, vanadium, manganese, molybdenum and uranium. Monitoring results indicate that Wagerup Refinery’s operations have not had an impact on surface water quality in the vicinity of the refinery. Surface water monitoring results are collated and reported annually to the DEC and DoW, in accordance with the DEC operating licence and DoW abstraction licences.

### 7.8.4 Guiding Principles and Alcoa’s Commitments

In response to the information provided, the Wagerup LTRMS SRG determined that a guiding principle relating to surface water was not required.

#### 7.9 Groundwater Impacts

##### 7.9.1 Background

Western Australia’s water resources are considered a valuable public asset. Groundwater of useable quality is present in the superficial strata within the region of the existing and proposed residue deposits.

Alcoa has a number of management strategies for protecting groundwater, including pipe and process equipment integrity and containment management programs. From the commencement of Alcoa’s operations in Western Australia, residue areas have been designed and constructed in accordance with contemporary accepted engineering standards which include containment and leachate recovery systems. These design standards have improved since Alcoa constructed its first residue areas at Wagerup.

The need to contain the residue leachate meant that the embankments were originally designed as water retaining structures that added further conservatism to their design. Their construction included base and embankment clay sealing layers.
The introduction of dry stacking of residue at Wagerup Refinery in 1991 reduced the potential for release of residue leachate to the surrounding environment as the lack of any significant water level within the deposit decreases the pressure on the base liners.

All drying areas have base drainage systems. These drainage systems provide a major defence against seepage to the ground water by substantially lowering the hydraulic head at the base of the deposit. All RSAs constructed since 1983 have also included PVC or HDPE liners to further mitigate seepage.

A schematic representation of RSA construction is provided in Figure 7-4.

Alcoa has a comprehensive groundwater monitoring program to monitor changes to groundwater levels and quality. Any losses from the residue areas are typically characterised by elevated total dissolved salts and elevated pH in the groundwater.

Ongoing groundwater monitoring at the residue areas has identified three areas that have been impacted by losses from the residue area. These losses are all attributable to the contemporary accepted engineering standards, which have improved since these areas were constructed. These areas are described in Section 7.9.2 below.

### 7.9.2 Current Management Strategies

Alcoa maintains and operates groundwater depressurising systems around the ROWS Pond, Cooling Pond, and ROCR2. The purpose of the depressurising systems at the ROWS Pond, Cooling Pond, and ROCR2 is to manage the groundwater levels beneath these facilities, and prevent upward pressures on the clay liners developing to an extent that could compromise liner integrity (Clifton, 2009). Alcoa has a licence issued by the DoW to operate these depressurising bores.

Alcoa also has a Groundwater Management Strategy for the Wagerup Refinery. The objective of this plan is to define, monitor, contain, control and reduce the known groundwater plumes originating from Alcoa Wagerup’s licensed activities, to protect the environmental values of Alcoa’s site and the immediate surrounds. This plan is regularly adjusted in response to feedback from monitoring at key sites.

As part of the Groundwater Management Strategy, Alcoa maintains two groundwater recovery bores at Wagerup to recover contaminated groundwater from a known groundwater plume. The performance of the recovery bores is monitored and tracked against target recovery flows. The effectiveness of the recovery bore network is monitored using an extensive network of groundwater monitoring bores; the results from this monitoring are reviewed and reported annually.

As part of the monitoring program, Alcoa continually assesses the need for additional recovery bores to improve the ability of the existing network to recover contamination and additional monitor bores to delineate and track the existing plume. On an annual basis, the extent of groundwater contamination is reviewed by an independent hydro-geologist.

### RSA 1, RSA 2 and Sand Area

Groundwater quality in the Upper Superficial Formation was previously inferred to have been affected by alkaline residue leachate in the vicinity of the earliest constructed residue facilities at RSA1, RSA2, and the Sand Area. This inference is not supported in general by the results of 2009 investigations in the southern half of RSA2 that concluded groundwater quality in this area has not been noticeably affected by alkaline process fluids (Gerritse and Thomas, 2009a, b). It is thought that presence of alkaline process fluids is a result of ingress into some of the older bores via the annulus around the monitoring casing.

![Figure 7-4: Schematic showing construction method of residue storage areas.](image-url)
Data from monitor bores around RSA 2 have implied the presence of varying levels of alkaline salts in groundwater samples. It has been unclear whether the elevated alkalinity has been due to leakage from the adjacent RSAs, or due to construction and maintenance issues with the monitor bores allowing alkaline water to enter either the bore casing or the bore annulus, or whether the alkalinity is naturally occurring. Investigations to determine the possible reasons for alkalinity in groundwater samples were carried out in 2007 and 2009. The investigations concluded that:

- The occurrence of elevated levels of alkalinity in some groundwater samples from the earlier monitor bores constructed in 1982 and 1989, particularly on the eastern wall of RSA 2, is localised and due to factors associated with bore construction; and
- There are no widespread effects on groundwater quality due to the presence of alkaline process fluids in either the Guildford Clay or Ascot Formation at RSA 2 South (Clifton, 2009).

**ROCP 1**

The quality of groundwater in the Upper Superficial Formation around ROCP1 in the residue area has also been affected by residue leachate. The clay liner of this facility is thought to have been damaged by upward groundwater pressures soon after construction in 1992. This has provided an opportunity for alkaline fluid to enter the shallow formations beneath the liner when water levels in ROCP1 exceed groundwater levels.

Alcoa has been managing and minimising the seepage from ROCP1 by keeping the level of water in this facility relatively low.

**7.9.3 Groundwater Monitoring**

A comprehensive groundwater monitoring program has been developed which details the frequency of monitoring, parameters to be analysed, and procedures to use for each monitoring location. Water quality monitoring includes measurement of pH, electrical conductivity, alkalinity, sodium/chloride ratio, aluminium, arsenic, boron, carbonate, calcium, cadmium, chloride, chromium, dissolved organic carbon, fluorine, iron, gallium, bicarbonate, hardness, mercury, potassium, magnesium, manganese, molybdenum, ammonia, total kjeldahl nitrogen, total nitrogen, sodium, nickel, Filterable Reactive Phosphorous, total phosphorus, lead, sulphate, selenium, silicon dioxide, total dissolved solids, uranium, vanadium, zinc, and ionic balance. Groundwater monitoring results are collated and reported annually to the DEC and DoW, in accordance with the DEC operating licence and DoW abstraction licences.

The primary objective of the Groundwater Monitoring Program is to assess the effectiveness of the groundwater management activities. More specifically this includes:

- Ensuring that groundwater quality is continuously monitored enabling identification of potential risks to environmental values;
- Assessing water quality effects and determine if water quality is changing over time;
- Monitoring the quality of the groundwater entering Alcoa’s property;
- Assessing the effectiveness of the management plan in protecting potential receptors i.e. to assess the effectiveness of preventing onsite plumes from spreading and impacting on potential receptors; and
- Assessing the effectiveness of the recovery system in preventing spread of plumes offsite into neighbouring land use areas.

**7.9.4 Guiding Principles and Alcoa’s Commitments**

In response to the information provided, the Wagerup LTRMS SRG developed two guiding principles relating to Groundwater. These are presented below, together with Alcoa’s response.

**Guiding Principle: Monitoring**

Alcoa to continue regular and systematic surface and groundwater monitoring in and around the RSAs based on Alcoa’s environmental licence conditions.
Visual amenity was raised as an important issue by the Wagerup LTRMS SRG.

7.10.2 Current Management Strategies
Recent projects completed as part of the Land Use Management Plan include:
• Protection and enhancement of existing wetlands and watercourses by establishing native vegetation / habitat corridors along banks, weed control, fencing to restrict stock access and stock watering facilities designed to minimise stream degradation;
• Monitoring the effectiveness of revegetation projects undertaken;
• Continued support for specific local land care projects by planting on Alcoa land to create habitat linkages as part of the Bancell Brook restoration project (conducted in partnership with Greening Australia and the Harvey River Restoration Trust);
• Revegetation and landscaping improvements, including weed control and planting of trees, shrubs and herbaceous plants at Lake Balga within the Bancell Rail Loop and the Alcoa Landcare Education Centre (ALEC);
• Continued infill planting along McClure and Somers Roads to improve the visual amenity of the residue area;
• Continued feral animal and weed control programs on Alcoa landholdings; and
• Establishment of a seed orchard.

A key objective of the Land Use Management Plan is improving the visual amenity of the residue areas. The focus of Alcoa’s visual amenity efforts is on the rehabilitation of external residue batters which are increasingly visible as the height of the residue storage areas increases. This residue rehabilitation program is outlined in Section 7.11. Landscape planting along roadsides is used to complement the rehabilitation program in high priority areas.

Alcoa has trialled changing the shape of the residue area by creating contours that match the natural low hills at the base of the Darling Scarp. Trials to modify the shape of the outer embankments of the residue area have commenced. To do this, slopes and contours in the natural environment were measured and incorporated into the northern embankment of RSA 8 at Wagerup Refinery. In addition, sharp corners have been avoided in new residue developments. However the impact of these variations in embankments depends on the viewing location, and tends to be more effective from a distance. The embankment trial is illustrated in Figure 7-5.

7.10.3 Visual Amenity Guiding Principles and Alcoa’s Commitments

In response to the information provided, the Wagerup LTRMS SRG developed two guiding principles relating to Visual Amenity. These are presented below, together with Alcoa’s response.

Guiding Principle: Visual Amenity Plan
Alcoa to regularly update the visual amenity plan to create a natural looking landscape. This plan should focus on identifying and developing strategies to enhance visual amenity at current and future visual amenity “hot spots” (including the South Western Hwy) and the maintenance of any established vegetation buffers. As part of this planning process, Alcoa should provide...
assistance to landholders to establish screening where appropriate.

Alcoa’s Response
Alcoa accepts and agrees with this principle. Alcoa will continue to develop and regularly update a visual amenity plan that will include progressive embankment rehabilitation and visual screening to make the residue areas appear as natural looking landscape as possible.

Guiding Principle: Light Emissions
Alcoa to develop and implement a strategy to mitigate unnecessary light emissions from the residue area whilst maintaining a safe work environment. This strategy should include informing the local community how they can provide feedback on light emissions.

7.11 Residue Area Rehabilitation

7.11.1 Background
There are two categories for the rehabilitation of the residue areas; these are progressive rehabilitation and final rehabilitation. Progressive rehabilitation is rehabilitation of an area concurrent with the operation of the area, which is carried out on the external embankments of the upstream sand embankments. Final rehabilitation is the final sand spreading, contour shaping, revegetation and dewatering of the RSA after closure.

This section outlines the strategy for progressive rehabilitation of the residue area. Final rehabilitation is addressed as part of the closure strategy discussion in Section 9.4.

The objectives of the residue rehabilitation program are to improve visual amenity of the external embankments, prevent the generation of dust, and enhance the conservation value of the area in order to achieve the progressive rehabilitation of the residue deposits.

7.11.2 Current Management Strategies
The current focus of the revegetation work undertaken at the Wagerup residue area is on external embankments (external embankments are embankments on the boundary of the residue footprint which are unlikely to be disturbed in the medium term). Outer embankments are commonly constructed using residue sand, produced after separation of the sand (>150 μm) from the residue mud (<150 μm). The alkaline (pH >10) and saline (> 10 dS/m) nature of residue, coupled with its poor water retention properties, poses numerous restrictions for optimal plant growth. To help overcome these restrictions, the
Residue sand embankments are left for a minimum of two years to allow leaching of excess alkalinity and salinity.

Wagerup’s current revegetation program for residue areas uses native species that are typically found on limestone outcrops and in coastal heath lands. These species are known to be tolerant of high pH and salinity and have been found to grow well in residue sand after it has been amended with gypsum (to reduce pH) and fertiliser (to supply nutrients). The incorporation of gypsum (Stage 1, Figure 7-6) alters the properties of residue to better reflect those of coastal sandy soils common to the Swan Coastal Plain of Western Australia. Previous rehabilitation practice incorporated gypsum to a depth of 0.8 metres, but this has been increased to 1.5 metres to allow deeper rooting of vegetation.

To provide a supply of plant nutrients at the time of planting, a custom blend of fertiliser is applied (Stage 2, Figure 7-6). Approximately 2.7 t/ha of di-ammonium based inorganic fertiliser is applied and incorporated to a depth of about 0.2 metres.

A mix of native seeds is broadcast over the area. The seed mix contains a range of species found on sandy soils over limestone and is reviewed progressively in response to their relative success. A 30 millimetre deep layer of coarse wood mulch is subsequently spread to prevent the generation of dust from the bare surface before plant cover has been established (Stage 3, Figure 7-6). In previous years, wood mulch from various sources contained weed seeds, resulting in weed infestation in the vegetation. Weed-free wood mulch is now being sourced from Alcoa’s mine sites, which should result in a reduction in weeds in the established vegetation. Follow up weed control using herbicides is also undertaken to prevent infestations.

The final step in revegetation operations is the hand planting of tree, shrub and groundcover seedlings at an approximate density of 1,200 stems/ha (Stage 4, Figure 7-6). These species are those that do not readily germinate from seed.

Up until 2006, irrigation was routinely used to aid the establishment and first two years of growth of vegetation; however, since 2006 this practice has ceased because irrigation was found to inhibit root penetration to depth. The native species used have adapted to these climatic conditions and, after establishment, will draw the water they need from the residue sand profile as root penetration increases with depth over time. Encouraging water extraction by the plants will assist in reducing the total volume of water that will eventually need to be treated prior to release or reuse. The role of the vegetation as a “store-release” cover system is currently being evaluated. A primary aim of the vegetation cover system is to conserve water and to encourage deep rooting, so that vegetation is sustainable. An example of the growth shown by one year old vegetation on residue embankments can be seen in Plate 7-2.

In response to concerns about visual amenity, Alcoa previously committed to rehabilitating external embankments with native vegetation in the first winter after construction of new embankment has been completed. However, vegetation planted in fresh embankments with minimal irrigation has not been as successful as previous embankment rehabilitation and has had failure rates requiring significant replanting. Further investigation has concluded that native vegetation is more successful when planted on embankments that have been allowed to leach the residual alkalinity from the soil profile. As a result, Alcoa now plants grass on external embankments for several years to allow rainfall to naturally leach the soil profile to decrease the pH and alkalinity levels. It has been observed that this practice often produces a better establishment and survival rate of the vegetation cover.

7.11.3 Further Research

Alcoa has a vision to be recognised as a world leader in residue rehabilitation and has a full time Residue Rehabilitation Research Scientist who leads the residue rehabilitation research program. The broad aims of the residue rehabilitation research program involve:

1. developing a fundamental understanding of the various physical, chemical and microbial characteristics that affect sustainable plant ecosystems on residue sand embankments;
2. applying this understanding to optimize the operational rehabilitation prescription to achieve acceptable vegetation cover; and
3. to extend the operational prescription to recommending suitable cover systems for closed RSAs.
Alcoa is currently focussed on better understanding the chemical, physical and microbial characteristics of rehabilitated residue sand embankments. Studies have found that the adsorption of nutrients and trace elements is markedly affected by pH and surface charge chemistry of residue sand, which exhibits a very high saturated hydraulic conductivity and poor water retention properties. The movement of water in residue sand profiles may be affected by increasing compaction with depth; and rehabilitation less than five years old demonstrates negligible microbial activity. Methods of improving the microbial communities in residue sand are currently being investigated by the University of Western Australia as part of an Alcoa-supported Australian Research Council (ARC) Linkage project.

Alcoa is investigating improvements to the current residue rehabilitation prescription by changes to the method of gypsum incorporation and investigating the suitability of alternative fertilisers. Improved gypsum incorporation has been achieved by using a finer grade (sieved) material and a ripping tine. Studies showed a more uniform distribution of gypsum within the residue profile compared with previous techniques.

Alternative fertilisers are currently being investigated as part of an ARC Linkage project at Griffith University (Brisbane). Preliminary studies have indicated that ammonium-based fertiliser may not be the ideal for use in alkaline residue sand, and that improvements to the composition of the fertiliser used may avoid excessive wastage.

Water dynamics have been a major focus of recent research as they will be an important long-term management issue. The proportions of rainfall that become deep drainage, are used by the vegetation, are lost via evaporation and are stored within the profile have been determined as part of the water balance. This work has been undertaken by the residue rehabilitation group, and by an Alcoa-funded project at the University of Western Australia. The findings from this work have been published within Alcoa, and in international peer-reviewed journals. Further research to model the larger scale water dynamics is currently planned.

A major outcome from research to date has shown how the properties of residue sand as a growth medium need to be improved. This has stimulated new research into the role of amendments (organic and inorganic) as a means of improving the quality of residue sand. Investigations have included amendments such as biosolids, green waste, biochar, zeolite, natural clay and residue mud (seawater neutralised and carbonated). This work has involved Murdoch University, the University of Queensland, Griffith University and the University of Western Australia. Future studies to apply the findings from these laboratory-based studies at the field scale are currently planned.

From 2009-12, Alcoa sponsored the formation of a Chair in Biogeochemistry at The University of Western Australia (Professor M Fey). A primary objective of this research program was to identify and develop soil quality criteria for determining when rehabilitation should commence, and plant performance criteria. Over this period, considerable progress has been made on improving the properties of residue for plant growth, and addressing limitations to residue rehabilitation performance. In 2010, Professor Fey was awarded an ARC Linkage grant to develop alternative embankment designs more suited to achieving sustainable ecosystems as part of RSA closure. This work is being completed in collaboration with other external research groups, and has recently trialled the construction of an alternative embankment at Kwinana as a means of controlling deep drainage. The application of this trial for improving native vegetation survival is currently being planned.

Alcoa frequently publishes the outcomes of the residue research work. Details of the publications are available on Alcoa’s website at http://www.alcoa.com/australia/en/info_page/mining_research.asp.
short and medium term residue development strategies

8.1 Residue Planning and Design Framework

Alcoa is in the process of updating the comprehensive residue management plan for the medium term (25 years) and life of the current mining lease (2045) and finalising the short-term (5-7 year) residue management plan for 2012-2019. These plans are developed giving consideration to the guidance provided through the LTRMS SRG process. Mud drying, dyke construction, planned maintenance and other sustaining activities are carried out in accordance with a detailed annual program of work, which is developed within the context of the five to seven year residue management plan.

Planning and design of all new residue facilities is completed in accordance with Alcoa’s Bauxite Residue Management Standard as well as relevant regulatory standards and guidelines. In addition to outlining the process to be followed when selecting and confirming the social, environmental and engineering suitability of areas for new residue facilities, these documents prescribe minimum design standards for all new facilities. For instance, detailed analysis is completed to confirm that the short and long-term stability of earthen embankments exceeds minimum requirements, and investigations are completed to ensure that all storm water generated from the residue area in a 1:100 wet year can be contained within the area without release to the environment.

8.2 Constraints on Forward Planning of Residue Operations

Despite the level of effort which goes into forward planning, significant changes are occasionally required as a result of a range of factors, including:

- changes in technology;
- changes at the refinery affecting the rate of production;
- changes in quality of bauxite and/or characteristics of residue material streams (the drying area required can be affected by small changes in the percentage of mud in the residue, with higher percentages of mud requiring a greater drying area);
- weather conditions, in so far as they can affect mud drying rates and the construction schedules of new residue areas;
- input from the community and regulatory agencies in the process of obtaining the necessary statutory approvals for new residue areas;
- internal funding availability, which is influenced by a number of factors including the global aluminium market; and
- availability of key equipment and contractors.

The plans presented in the LTRMS are therefore subject to change, particularly in timing and sequencing. The five yearly review process for the LTRMS is designed
to allow these changes and their impact on long-term planning for the residue area to be reviewed with community and government stakeholders. In the event that a significant change will impact the five to seven year plan presented in this document, additional consultation may be required.

The current LTRMS identifies the:
- current projected residue footprint for 2012-2019;
- current proposed area over which the residue area may expand during the next 25 years (to 2038); and
- current preferred area over which the residue area may expand during the life of the current mining lease (2045).

8.3 Future Residue Planning

Alcoa’s future residue planning work is focussed on two key streams of work that are progressed in parallel:
1. Research to identify mechanisms to reduce the area required for future residue storage; and
2. Future planning based on current storage techniques.

8.3.1 Research to Reduce Residue Areas

Alcoa is dedicated to continually investigating new markets, products and technologies that may lead to a reduction in the area required for future residue storage. This work is currently focused in three key areas:
1. Alternative uses for Residue.
2. Reducing required drying area/time.
3. Alternative storage technologies and processes.

Alternative Uses for Residue

Alcoa has been developing alternative uses for bauxite residue since 1978. Alcoa recognises that if significant alternative uses of residue can be achieved, the rate of expansion of the residue area can be slowed, and the long-term impacts of residue storage can be reduced. See Section 4.6 for more detail on Alcoa’s residue reuse research.

Reducing Required Drying Area and Time

Alcoa’s uses a drying model formula to assist in its residue planning. This formula helps Alcoa to determine the drying area required to ensure that the mud can dry sufficiently to gain the required strength. This formula can be simplistically represented as:

\[
\text{drying area required} = \frac{\text{tonnes mud per day} \times 100 \text{ days} / \text{mud density} / \text{pour depth}}
\]

Alcoa is currently studying ways to reduce the number of days of required drying time, and hence the drying area required. If improved drying times can be achieved whilst maintaining the structural integrity of the residue areas, this would reduce the rate new residue areas are required. To do this, Alcoa is trialling alternative amphirolling cycles and the use of flocculants which may assist to dewater the residue.

A flocculant product called Rheomax is currently being trialled by Alcoa in Western Australia. Rheomax is a polyacrylamide/acrylate mixture that is chemically equivalent to the flocculants currently used in the super-thickener. It is added at the end of the residue pipe at very low rates, just before the residue is deposited in the RSA.

Alternative Storage Technologies and Processes

Alcoa is currently undertaking preliminary investigations into the possibility of introducing large scale filter presses in WA. The filter presses essentially work by forcing the moisture out of the residue, leaving behind a dry filter cake. If these filter presses prove a viable option for the Wagerup Refinery’s residue area, this could have a number of advantages:
- Residue operations could be sustained within the current footprint for approximately the next 20 years;
- Residue water use would be significantly reduced;
- Reduced potential to produce dust from the drying areas; and
- Reduced potential to impact groundwater.

Alcoa will continue to investigate the feasibility of press filters for bauxite residue, and if implementation is an option before the next LTRMS review, will conduct a further consultation process to provide stakeholders with the opportunity to have input to the implementation plans.

8.3.2 Future Planning Based on Current Storage Techniques

Although Alcoa is actively pursuing mechanisms to reduce the area required for future residue storage, due to the long lead times required for planning, Alcoa must continue its future residue planning based on the current storage techniques, until any alternative mechanism is proven and fully implemented.

The future residue strategies presented in the remainder of this chapter are therefore based on the current residue storage techniques.

8.3.3 Residue Storage Techniques Guiding Principles

In response to the information provided, the Wagerup LTRMS SRG developed one guiding principle relating to the residue storage techniques. This is presented below, together with Alcoa’s response.
Guiding Principle
Alcoa to actively pursue alternative residue storage and reuse technologies with the objective of reducing the required residue area, and trial these technologies at Wagerup wherever possible.

Alcoa’s Response
Alcoa accepts and agrees with this principle. Alcoa considers a number of factors when selecting a site to trial new technology and processes. These factors include the location of suppliers or customers and compatibility with current processes. Where trials of new technology and processes prove successful, Alcoa’s aim is to implement the proven technology or process improvements wherever feasible.

8.4 Residue Area Planning Considerations
As the mud elevation in drying areas increases over time, perimeter embankments progressively move inwards and the net available drying area reduces. As a consequence, to maintain the minimum drying area required to dry mud, it is necessary to periodically construct new drying areas. Alcoa uses a number of principles in its planning processes to plan for new residue areas. These include greenfield site assessment, footprint development direction, residue stack heights, and proximity to neighbours.

Alcoa assesses the various options for new residue area development based on sustainability criteria. The following provides some examples of the considerations that are made in this assessment of each option.

8.4.1 Greenfield Site Assessment
Alcoa assesses the various options for new residue area development based on sustainability criteria. Table 8-1 provides examples of the considerations that are made in this assessment of each option.

8.4.2 Development Direction
Alcoa has assessed options to expand the residue area to the north, south, east and west in accordance with Alcoa's sustainability criteria, as outlined in Table 8-1. A summary of this assessment for each option is presented below.

Table 8-1: Sustainability criteria used to assess footprint options.

<table>
<thead>
<tr>
<th>Economic</th>
<th>Environmental</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cost of construction (pumping, piping, infrastructure relocation). • Associated costs such as relocation of key infrastructure such as powerlines and water pipelines.</td>
<td>• Potential impact on protected species and ecologically sensitive areas. • Potential dust and odour impacts. • Ground water levels. • Ability to achieve necessary approvals.</td>
<td>• Potential impact on any heritage sites (Aboriginal and European). • Visual amenity impacts. • Potential impact on neighbours.</td>
</tr>
</tbody>
</table>

Northern Expansion
Expansion of the residue area to the north has the benefits of allowing the new residue areas to adjoin the existing stack, and having minimal environmental impact due to good hydrogeology in the area, and limited native vegetation. The land in this area is already owned by Alcoa.

Expansion in this direction will be impacted by major powerline infrastructure in the area, and will bring the residue area closer to neighbours and the Hamel township. The land in this area is also considered to be of high agricultural value.

Alcoa currently considers northerly expansion of the residue area a preferable option.

Southern Expansion
Expansion of the residue area to the south has the benefits of allowing the new residue areas to adjoin the existing stack, and having minimal environmental impact due to good hydrogeology in the area. However, the land to the south of the existing residue area is not currently owned by Alcoa, and expansion in this direction would require the relocation of the drain, road and gas infrastructure. Expansion in this direction would also bring the residue area closer to neighbours and would impact on land considered to be of high agricultural value.

Alcoa does not currently consider expansion of the current residue area to the south as a preferable option.

Western Expansion
Expansion of the residue area to the west has the benefits of allowing the new residue areas to adjoin the existing stack, utilising land of lower agricultural value, and maintaining separation of the residue area from the townships of Hamel and Yarloop. The land in this area is already owned by Alcoa.
Expansion in this direction will be impacted by Somers Road and major water pipelines in the area, and will require clearing of native vegetation.

Alcoa currently considers westerly expansion of the residue area a preferable option.

**East Expansion**

Expansion of the residue area to the east would provide the benefit of maintaining separation of the residue area from the townships of Hamel and Yarloop.

Expansion in this direction would be constrained by the presence of drain, railway, water, gas and power infrastructure, and the South Western Highway. Expansion in this direction would also require the relocation of Alcoa’s water storage ponds and would result in an inefficient design of the residue area as the new residue areas would be separated from the existing stack. Furthermore, the hydrogeology in this area is not ideal for residue areas.

Alcoa does not currently consider expansion of the current residue area to the east as a preferable option.

**North West Expansion**

Expansion of the residue area in a north westerly area would provide the benefits of both the north and west expansion options, and would allow for a smaller expansion of the residue footprint in both of these directions than would occur if expansion was only progressed in one of these directions.

Alcoa currently considers expansion in a westerly direction followed by a northerly expansion the preferred option.

### 8.4.3 Height

During the 2007 LTRMS review, in response to the feedback received from the 2007 Wagerup LTRMS Working Group, Alcoa committed to not increase the height of the residue stack above 40 metres above natural ground level before 2012. Alcoa fulfilled this 2007 commitment, and the current height of the residue area is 29 metres above natural ground level (43 metres RL). Alcoa also committed at that time that the mid-term residue footprint plans would be developed on a reduced height of 60 metres above natural ground level (74 metres RL) as this will produce the most sustainable outcomes (Alcoa’s other WA sites have 25 year life-of-mine footprints based on residue heights of 80 metres).

Residue height was again a significant issue raised during the development of this LTRMS by the 2012 SRG members. The SRG members raised concerns relating to visual amenity and dust management impacts associated with higher residue stacks. Alcoa acknowledges the stakeholder feedback received during the 2007 and 2012 reviews of the LTRMS and understands the desire for Alcoa to work towards the residue drying area not exceeding 40 metres above natural ground level.

Alcoa has taken all of the input of the 2012 Wagerup LTRMS SRG into consideration in the development of this LTRMS. As a result of this review, Alcoa has resolved to continue developing the residue stack to 60 metres above natural ground level (74 metres RL) as this will be the most sustainable option in terms of environmental, social and economic outcomes. Economically, an increased stack height has the benefit of requiring less land to store residue, and hence reduces capital costs. Socially, increased stack heights allows greater separation distances from storage areas to neighbours and reduces the overall land area which may have long-term planning constraints. Environmentally, a reduced footprint reduces the area at risk of future groundwater contamination and supports a range of alternate use and land use options.

Having an LTRMS based on these increased stack heights also provides an outcome that fulfils a number of the other guiding principles provided by the SRG, such as:

- **Residue Odour and VOC Emissions** – An increased stack height will result in a reduced surface area from which odour and VOC emissions can potentially be produced;
- **Groundwater** – An increased stack height reduces the residue footprint and reduces the potential for groundwater contamination;
- **Separation Distance** – An increased stack height will allow Alcoa to maximise the separation distance between the residue stacks and privately owned property; and
- **Closure** – An increased stack height reduces the footprint of land occupied by residue at closure, and reduces the surface area that will capture water that will require treatment and disposal post closure of the residue areas.

It is acknowledged that increased stack heights will make the residue area more visible, and may provide greater challenges for dust management. Visual amenity and dust management issues associated with increased residue heights were key concerns raised by both the 2007 and 2012 LTRMS SRGs. Continual improvement of the visual amenity, dust management and residue rehabilitation programs remains a key focus for residue management and Alcoa will continue to keep the community informed of progress in these areas.

### 8.4.4 Separation Distance to Near Neighbours

The separation distance between the residue area and private property and/or residences was discussed with the 2012 Wagerup LTRMS SRG.

The extent of the residue area is a function of a number of variables including:

- The height that the residue stacks are built to;
- The production rate and commissioning timeframe for the expanded refinery;
- The possible need to realign the Alinta owned power lines along Kubank Road;
- The requirement to maintain an adequate separation distance to near neighbours;
- Zoning approval for the 25 year footprint; and
- Ownership of land, and hence
The height that the residue stacks are built to;

- Separation achieved to near neighbours, and
- Land available for residue storage.

Alcoa implemented a land management strategy in 2001-02 around the Wagerup Refinery which enabled people living in the immediate vicinity who felt impacted by the operations to sell property to Alcoa. The Strategy comprises of two areas:

- Area A – immediately surrounding the refinery; and
- Area B – the townships of Yarloop and Hamel.

The Land Management Strategy is implemented by Alcoa and has no formal status in planning schemes or legislation, and encompasses both the refinery and residue area.

Alcoa will continue to implement the existing Land Management Strategy which was designed to allow for the future expansion of the residue area. See Section 6.6.1 for more information on Alcoa’s Land Management Strategy.

8.4.5 Residue Area Planning Guiding Principles

In response to the information provided, the Wagerup LTRMS SRG developed three guiding principles relating to the residue area planning. These are presented below, together with Alcoa’s response.

Guiding Principle: Separation Distance

Alcoa to maintain a 2 kilometre separation distance between the boundary of the residue area and private property and/or residences.

Alcoa’s Response

Alcoa is committed to the current Land Management Strategy and will endeavour to maximize the separation distance to private residences. It must be noted that the extent of the midterm drying area footprint is a function of a number of variables including:

- The height that the residue stacks are built to;
- The production rate and commissioning timeframe for the expanded refinery;
- The possible need to realign the Alinta owned power lines along Kubank Road;
- The requirement to maintain an adequate separation distance to near neighbours;
- Zoning approval for the 25 year footprint; and
- Ownership of land, and hence
  - Separation achieved to near neighbours; and
  - Land available for residue storage.

Guiding Principle: Footprint and Height

The Stakeholder Reference Group recommends that residue expansion into the future will be in a westerly direction at 40 metres above natural ground level, but Alcoa needs to:

- Implement a residue reuse program as a matter of urgency (as per the Residue Reuse Guiding Principles);
- Improve visual amenity (as per the Visual Amenity Guiding Principles);
- Improve dust management (as per the Dust Management Guiding Principles); and
- Improve outer bank revegetation (as per the Visual Amenity and Residue Rehabilitation Guiding Principles).

Alcoa’s Response

Alcoa acknowledges that the Stakeholder Reference Group would like to see a residue reuse program implemented, and improvements in visual amenity, dust management and residue rehabilitation. Alcoa is committed to continuing to evaluate a residue reuse program and improvements in these environmental aspects.

During the 2007 LTRMS review, in response to the feedback received from the 2007 Wagerup LTRMS Working Group, Alcoa committed to not increase the height of the residue stack above 40 metres above natural ground level before 2012. Alcoa fulfilled this 2007 commitment, and the current height of the residue area is 29 metres above natural ground level (43 metres RL). Alcoa also committed at that time that the midterm residue footprint plans would be developed on a reduced height of 60 metres above natural ground level (74 metres RL) as this will produce the most sustainable outcomes (Alcoa’s other WA sites have 25 year life-of-mine footprints based on residue heights of 80 metres).

As a result of these forward plans, in the coming 5 year period (to 2017) Alcoa will build part of the residue area up to a height of approximately 45 metres above the natural ground level (59 metres RL). In this coming five years, the area planned to be developed up to this height will be a maximum of 10 hectares. The additional drying area that this will provide will ensure that the refinery has sufficient residue storage area, the mud has sufficient time to dry to the required strength, and that there is sufficient water storage capacity within the residue area.

Alcoa has reviewed its medium term (25 years) plans, taking into consideration the input of the 2012 Wagerup LTRMS SRG. As a result of this review, Alcoa has resolved to continue developing the residue stack to 60 metres above natural ground level (74 metres RL) as this will be the most sustainable option in terms of environmental, social and economic outcomes, and is in line with a number of other guiding principles developed by the Stakeholder Reference Group, such as:
8.5 Life-of-Mine Strategy (2045)

Based on the considerations outlined in Section 8.4, Alcoa has developed an indicative life-of-mine strategy for the residue area. This strategy assumes that the proposed Wagerup 3 expansion is implemented, the residue stacks are developed to a height of 60 metres above natural ground level (74 metres RL) and that the footprint is expanded in a westerly then northerly direction.

8.6 Mid-Term Strategy (25 years)

The key issues to be managed within the next 25 years include:

- maintaining the residue storage and drying capacity to meet the requirements of the refinery,
- maintaining the water storage, surge capacity, cooling and process water supply functions for the refinery, ensuring they can service the increased drying areas, and
- relocation of infrastructure required to support the provision of adequate residue drying and water storage capacity.

Within the next 25 years, assuming current production rates, up to 250 hectares of additional drying area is required. Projects designed to provide approximately 80 hectares of the required drying area are currently planned to be constructed between 2012 and 2019, and are presented in Sections 8.7. It is currently envisaged that this additional drying area required will be met through development of greenfield drying areas.

The remaining mid-term residue construction activities required include:

- construction of ROCP 4 to provide sufficient rainfall runoff storage capacity; and
- relocation of infrastructure, as required, to support the above projects.

8.6.1 Residue Drying and Storage

RSA 11

The development of RSA 11 is currently planned to provide approximately 40 hectares of additional drying area. Current plans indicate that construction of RSA 11 is likely to commence in 2019-20, however this is subject to the constraints outlined in Section 8.2. The indicative location of RSA 11 is shown in Figure 8-1.

RSA 12

The development of RSA 12 is currently planned to provide approximately 45 hectares of additional drying area. Current plans indicate that construction of RSA 12 is likely to commence in 2024-25, however this is subject to the constraints outlined in Section 8.2. The indicative location of RSA 12 is shown in Figure 8-1.

RSA 13

The development of RSA 13 is currently planned to provide approximately 70 hectares of additional drying area. Current plans indicate that construction of RSA 11 is likely to commence in 2028-29, however this is subject to the constraints outlined in Section 8.2. The indicative location of RSA 13 is shown in Figure 8-1.

RSA 14

The development of RSA 14 is currently planned to provide approximately 45 hectares of additional drying area. Current plans indicate that construction of RSA 11 is likely to commence in 2034-35, however this is subject to the constraints outlined in Section 8.2. The indicative location of RSA 14 is shown in Figure 8-1.
8.6.2 Water Storage

ROCP 4

Rain that falls on the RSAs is collected in Runoff Collection Ponds. As the residue footprint expands, increased capacity to store the rainfall runoff is required. Construction of an additional ROCP (ROCP 4) will be required to provide adequate rainfall runoff storage for the new residue areas that will be built. ROCP 4 will be built on land owned by Alcoa, in accordance with Alcoa’s latest standards which comply with relevant regulatory requirements. Construction of ROCP 4 is currently planned for approximately 2019-20.

8.7 Short-Term Construction Strategy (5-7 years)

Key issues to be managed within the next five to seven years are:

- maintaining the residue storage and drying capacity to meet the requirements of the refinery, and
- maintaining the water storage, surge capacity, cooling and process water supply functions for the refinery, ensuring they can service the increased drying areas.

Projects designed to provide approximately 80 hectares of the new drying area are currently planned to be constructed between 2012 and 2019. These are outlined in Section 8.7.2.

8.7.1 Business as Usual

The following ‘business as usual’ construction activities will be carried out over the period 2012 to 2019:

- periodic raising of perimeter and internal embankments to maintain the freeboard necessary to support proposed mud deposition activities and provide the capacity needed to contain runoff during extreme 1:100 year, 72 hour storm conditions within the individual RSAs; individual dyke raises involve construction of a new embankment with a crest level typically between 4 and 10 metres higher than the previous crest level;
- construction and/or relocation of infrastructure associated with the embankment lifts;
- construction of new underdrainage systems associated with hydraulic placement of sand in new embankment walls and/or stockpiles;
- installation of new decant structures, and/or relocation of existing decant structures, and associated pipework;
- extension/modification of mud and sand distribution pipework;
- extension/modification of the groundwater bore monitoring network;
- extension of sprinkler risers; and
- construction of new roads.

A number of techniques are used to raise embankments. Where practical and cost effective, the preferred method is to construct the embankments using hydraulically placed residue sand. However, it is sometimes necessary to construct residue sand embankments using mechanical placement techniques (e.g. using scrapers, dump trucks and rollers) and/or raise embankments using mud sourced from the drying areas whereby mechanical placement and compaction techniques are again necessary.

8.7.2 Residue Drying and Storage
As the mud elevation in drying areas increases over time, perimeter embankments progressively move inwards and the net available drying area reduces. As a consequence, to maintain the minimum drying area required to dry mud it is necessary to periodically construct new drying areas. Over the period 2012-2019 Alcoa currently plans to provide new drying areas for current production rates through construction of two greenfield drying areas, RSA 9 and RSA 10, on Alcoa owned land within the Industrial zoned area to the west of the current areas, providing approximately 80 hectares of drying area. A new ROWS Pond and Run Off Collection Pond (ROCP) will also be built to provide adequate water management capability.

In the coming 5 year period (to 2017) Alcoa will build part of the residue area up to a height of approximately 45 metres above the natural ground level (59 metres RL). The area planned to be developed up to this height in this coming five year period will be a maximum of 10 hectares. The additional drying area that this will provide in addition to the new drying areas described here, will ensure that the refinery has sufficient residue storage area, the mud has sufficient time to dry to the required strength, and that there is sufficient water storage capacity within the residue area. See Figure 8-1.

RSA 9
Construction of RSA 9 is currently underway. RSA 9 is being built on land owned by Alcoa, in accordance with Alcoa’s latest standards for drying areas which comply with relevant regulatory requirements. For example, RSA 9 is being built with:
- A composite lining system, comprising of a layer of compacted clay with an overlying synthetic liner, coupled with an under-drainage system to minimize the hydrostatic pressure on the liner;
- A sprinkler system designed on a 60 m by 60 m triangular spacing; and
- Sufficient storage capacity to store runoff generated during a 1 in 100 year 72 hour storm event, and provision to transfer this water to the ROWS pond.

The location of RSA 9 is shown in Figure 8-1. RSA 9 will provide an additional 40 hectares of residue drying area. Commissioning of RSA 9 is planned for 2014, however this timeframe is subject to the constraints outlined in Section 8.2.

RSA 10
Alcoa currently plans to begin construction of RSA 10 in 2016, after RSA 9 is commissioned. This is subject to the constraints outlined in Section 8.2. RSA 10 will be built on land owned by
Alcoa in accordance with Alcoa’s latest standards for drying areas which comply with relevant regulatory requirements.

The nominal location of RSA 10 is shown in Figure 8-1. RSA 10 will provide an additional 40 hectares of residue drying area. Commissioning of RSA 10 is currently planned for 2017.

8.7.3 Water Storage

Run Off Collection Pond (ROCP) 3

Rain that falls on the RSAs is collected in Runoff Collection Ponds. As the residue footprint expands, increased capacity to store the rainfall runoff is required.

Construction of the new ROCP 3 is currently underway. ROCP 3 is being built on land owned by Alcoa, in accordance with Alcoa’s latest standards which comply with relevant regulatory requirements. ROCP 3 is being constructed with a composite clay and HDPE liner and an underdrainage system to allow it to be easily replaced and converted into a future residue drying area if required.

Commissioning of ROCP 3 is planned for 2013, however this timeframe is subject to the constraints outlined in Section 8.2.

ROCP 3 will be approximately 17 hectares in size and will provide approximately 435 ML of water storage capacity. ROCP3 will replace the function of the existing ROCP 1 which is currently planned to be decommissioned once ROCP 3 is complete.

The location of ROCP 3 is shown in Figure 8-1.

8.8 Planning Strategy to Support Future Residue Development Requirements

8.8.1 Environmental Studies

Although the indicative location of possible future drying areas required for the life-of-mine has been determined, the actual footprint for these areas will be finalised in response to further studies of the area. These studies will typically include flora, fauna, heritage and hydrology studies. Results of these studies will inform future LTRMS reviews.

8.8.2 Land Use Zoning and Government Approvals

Part of the required land for the 25 year footprint is currently zoned as Industrial. Alcoa plans to submit applications to rezone the remainder of 25 year footprint within the Peel Region Scheme and Shire of Waroona local planning scheme to industrial zoning in 2013-14. Figure 8-1 shows the current industrial zoned area and the area that will require rezoning.

8.8.3 Land Use Planning Guiding Principles

In response to the information provided, the Wagerup LTRMS SRG chose not to develop any guiding principles relating to Alcoa’s planning strategy to support future residue development requirements.
The process of defining the closure strategy will be ongoing. Final closure of the Wagerup residue area is many years away, and available technology and community opinions regarding final land use may change over time.

The current closure strategy has three main objectives, being that decommissioned residue areas should:

1. have the capability to be used for productive community benefit;
2. be a safe and self-sustaining structure in the long-term; and
3. allow future access to residue for alternate uses.

Development of alternative uses for bauxite residue has been one of the major objectives of Alcoa’s residue development program since 1978. The current programs are described in detail in Section 4.6.2. The focus on reuse of the product to reduce the final volume of residue remaining on the site after closure is a key consideration in assessing alternate closure strategies.

9.1 Closure Strategy Options

The rehabilitation of the residue deposits will be ongoing during the operating life of the refinery. The perimeter embankments will be rehabilitated as the height of the stack grows, and revegetation of the surface of the drying beds will occur as each reaches its nominated final elevation.

At the time of refinery closure, much of the rehabilitation will be complete with only the minimum drying area remaining to be closed.

At the time the residue deposits are closed, the residue will still contain large quantities of leachable alkali. If rainfall is allowed to infiltrate the deposit, the alkali will be leached from the residue and will report to the underdrainage system. There are two basic options for closure of the residue deposits which have been considered. The first is to provide an impermeable cover to the residue deposits, effectively encapsulating the alkalinity within the deposit and shedding rainfall. The second is to allow rainfall to infiltrate the deposit and set up ongoing collection and treatment facilities for the alkaline water that will be collected. These two options are further discussed below.

9.1.1 Encapsulation

At the time of closure, a surface seal (with similar permeability characteristics to the base seal) would be installed over the deposit and the drainage system turned off. This surface seal would exclude rainfall infiltration to prevent re-saturation of the deposit which, if allowed to occur, would increase the head on the base seal and increase the rate of seepage. The surface seal would be protected by an overlying residue sand layer.

With this option, the leachable alkali remaining in the deposit at the time of closure would be ‘encapsulated’ within the deposit. The surface runoff water may initially be alkaline due to the alkalinity of the surface residue sand layer. Continuous rainfall leaching of this surface sand layer would, over several years, reduce the alkalinity of the runoff to the point where no treatment would be necessary prior to release.
9.1.2 Continued Leaching
This option assumes that leaching of the deposit would continue beyond the operating life of the refinery. Seepage of rainfall through the residue stack would be encouraged, maximising the recovery of leachable alkali, while maintaining a low hydrostatic head on the base seal. As for the encapsulation option, it should be possible to release surface runoff water without treatment after several years of rainfall leaching of the residue sand capping layer. However the water which passes through the stack and is collected via the internal drainage system would continue to leach alkalinity from the stack. This water is likely to require treatment if it is to be released to the environment for some further period of time.

9.2 Current Closure Strategy
Based upon current disposal technology and the experience Alcoa has gained over the past 30 years with bauxite residue management in Western Australia, Alcoa presently believes that continued leaching of the deposit beyond the time of closure is the preferred approach for closure of bauxite residue deposits. This approach will lead to remediation of the deposit over time.

A schematic representation of a residue stack area at closure is provided in Figure 9-1. During construction, a sand drainage layer containing drainage pipes is placed above a compacted clay liner and a PVC liner at the base of the stack. Residue mud is then stacked, within the sand dykes which form the perimeter embankments. Upon closure, the area is revegetated in a manner that meets the agreed future land use objectives for the site. This may include placing a sand capping layer over the stack prior to revegetation, which will assist in controlling wind and water erosion of the stack.

When the refinery closes, the alkaline water collected via surface runoff and under drainage will no longer have a use as makeup water. If there are no other commercial uses for the water, it will need to be treated and released to the environment. The surface runoff water and drainage water from the deposit will be managed to ensure the alkalinity does not cause environmental damage. The volume of water to be collected, the alkalinity of the water, and the timeframe over which treatment will be required are unknown at this stage. However options for treatment and discharge of this water have been investigated, and a likely range of costs developed for inclusion in closure funding. Options for the treatment of leachate from the residue stack are discussed in Section 9.3.

The advantages of this closure strategy include:
- continued leaching of the residue will reduce its alkalinity, therefore reducing the potential for environmental impacts over time;
- during the life of the refinery the drainage will be returned to the refinery thereby eliminating the need for treatment;
- contouring and revegetation of the outer slopes of the deposits can be done progressively;
- establishment of a wide range of vegetation types will be possible, limited initially by the alkalinity of the residue, but progressively improving as leaching continues;
- the deposit will be suitable for a wide range of end uses; and
- the residue will be readily accessible if alternate uses for the residue are able to be commercialised.

Decommissioned residue areas will have the capability to be used for productive community benefit. Currently, the residue rehabilitation research is focused on establishing a native vegetation cover utilising coastal dune species. We consider this to be appropriate as:
- it is self sustaining once established;
- provides an aesthetic buffer to the landform; and

![Figure 9-1: A schematic representation of a residue area at closure.](image)
• can be readily adapted to other land uses (agriculture, industrial) at a future time if required.

As described in Section 7.11 research is also underway to quantify the soil-water plant dynamics in residue rehabilitation. This research is designed to identify suitable closure vegetation cover options and to quantify post-closure water balance within the residue stack. To date, much of this work has focussed on the residue sand embankments as these areas are being progressively rehabilitated. More complex studies will be required to understand and model water transport in the entire stack.

9.3 Water Balance/Discharge Management

As the residue deposits are closed, a vegetated surface will be established. Both rainfall and liquor will continue to leach through the deposit and will be collected by the base drainage system as an alkaline leachate. These waters will need to be treated prior to reuse, or be required to understand and model water transport in the entire stack.

The volume of alkaline drainage water produced will depend on the water use of the established vegetation and the land area covered by residue. The most effective way of reducing the volume of alkaline drainage water requiring ongoing management is to have the smallest residue footprint that meets operational needs. The selection of vegetation planted on the closed area then has the next biggest impact on the volume of water passing through the residue stack.

One of the current focus areas for residue rehabilitation research is to maximise the water use from vegetation so that the volume of leachate requiring treatment is reduced. As outlined in Section 7.11, this also involves the incorporation of amendments which increase the water retention properties of residue sand.

A range of options for the management of the excess water have been identified, including:

• treatment and discharge to ocean or local surface water;
• managed aquifer recharge; and
• treatment and reuse (e.g. for stock irrigation, industry or potable use).

Further assessment of these options requires identification of background water quality parameters for potential receiving water bodies, a review of the pertinent standards relating to different water sources and their uses, assessment of the treatment options, cost implications and processes for discharge. The SRG encouraged Alcoa to progress this work as a priority in order to inform future consultation with stakeholders and the broader community on the preferred options.

The benefits of successfully reducing the pH of the residue leachate will be recognised at closure when the level of treatment of waters prior to reuse, and the timeframe over which treatment is required, should have reduced due to rainfall leaching of the stack. Water treatment options post closure will be impacted by Alcoa’s ability to implement methods of pH reduction of residue, such as carbonation, or to manage alkalinity levels reporting to the residue area during active operations.

9.4 Future Land Use Options & Revegetation

The residue areas are shaped to a final land form that can support a range of passive and active uses. In considering future land use options, Alcoa aims to ensure the long-term sustainability of the area, while encouraging its use in a manner that enables greatest community benefit.

The current rehabilitation program is designed to maintain flexibility such that a range of final land uses can be considered.

An example of a final land use is Area ABC at Alcoa’s Kwinana Refinery, which has been successfully redeveloped as the Perth Motorplex. Opened in December 2000, the facility has become the premier Perth venue for automotive based activities including drag racing, dirt track speedway, burnout competitions, street machine car shows, monster trucks, stunt shows and super cross events.

In 1994, a section of closed drying area was set up at the Pinjarra Refinery to demonstrate a range of land uses for the Western Australian residue areas. These land use options include plantations of native trees, native shelterbelts, irrigated lucerne, olives, vine rootstocks, dryland and irrigated pastures. Soil and plant analyses were undertaken routinely to determine productivity and fertiliser requirements and to monitor soil development on the residue and results from the demonstration site are described in detail in a number of annual reports and triennial reports to the DEC (Alcoa, 2005). More recent sampling by the residue rehabilitation research group has also been undertaken in 2010 to evaluate long-term changes in residue sand properties, which will assist in establishing soil quality indicators and rehabilitation performance criteria.

Sheep and cattle have also been grazed on pastures on the demonstration area, and blood and tissue samples monitored routinely to identify any adverse effects on animal health of grazing residue areas. The results show that sheep and cattle grazed on residue areas maintain good health and do not develop marked mineral imbalances. There is also no evidence of heavy metal retention. In addition, Alcoa’s commitment to focussed research will develop guidelines for establishing a sustainable ecosystem on residue storage areas, both under operating and closed conditions (Section 7.11). Current research is identifying ways to improve the characteristics of residue to make it more favourable to plant growth, and to evaluate whether the current rehabilitation prescription can produce an effective store-release cover system to help manage deep drainage.

The dry stacks are being constructed in a manner that leaves the way open for a number of possible future land uses. Residue sand is being used to construct...
the outer embankments and base drainage systems, and to provide a layer of free draining sand on the outer slopes of the deposits. The high permeability of residue sand ensures all water entering the residue surface is retained within the stack, and negligible runoff occurs. The current design therefore eliminates significant erosion of the embankment surface under typical weather conditions.

The height and shape of the residue area at closure is also an important characteristic. As the height of the stack increases, the outer slopes created by raising the perimeter embankments will be progressively contoured using residue sand and vegetated. Any requirements for drainage and runoff control will be installed as the embankments are raised. These outer slopes will comprise approximately one third of the total area occupied by residue.

At each review of the LTRMS the opportunities for future use will be reviewed with the community and strategies will be updated on a five yearly basis. This will ensure the options being investigated remain consistent with the needs of the community and Alcoa.

9.5 Closure Funding
Alcoa will abide by all statutory, corporate and relevant accounting standards that apply to residue management and ensure adequate provision is made so that there is no liability to the State.

9.6 Closure Guiding Principles and Alcoa's Commitments
In response to the information provided, the Wagerup LTRMS SRG developed five guiding principles relating to closure. These are presented below, together with Alcoa’s response.

Guiding Principle: Water Treatment
Alcoa to investigate and pursue strategies to reduce the volume of water that will require treatment both during the life of the refinery and post closure.

Alcoa’s Response
In considering any new technology or process, Alcoa evaluates a range of factors including implications for water management both during and post closure of the refinery. Alcoa is undertaking studies on the water balance of the residue areas with the aim of identifying opportunities to modify the residue rehabilitation prescription and embankment design to reduce volume of drainage water requiring ongoing management.

While the refinery is operating, all water collected from the residue area is recycled to the refinery for reuse, and the residue area is a significant water source for the refinery.

Alcoa will continue to undertake these further investigations to identify and investigate possible options for post closure water management between now and closure of the refinery.

Guiding Principle: Water Treatment
Alcoa to further investigate options for water treatment and discharge post closure of the refinery.

Alcoa’s Response
Alcoa accepts and agrees with this principle.

The process of defining the closure strategy will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes may change.

The current LTRMS review will not be able to identify the appropriate final strategy for post closure water management but will identify the need for further investigations to occur.

Alcoa will continue to undertake these further investigations to identify and investigate possible options for post closure water management between now and closure of the refinery.

Guiding Principle: Final Land Use and Land Form
Alcoa to continue to improve residue management to maximise the options for final land use and land form.

Alcoa’s Response
Alcoa accepts and agrees with this principle.

Guiding Principle: Closure Management Plan
Alcoa to develop an adequate closure management plan to ensure the local community is not left with a legacy of adverse impacts after the refinery is closed.

Alcoa’s Response
Alcoa accepts and agrees with this principle.

In accordance with conditions of Ministerial Statement No 728, Alcoa has submitted a preliminary decommissioning plan to the DEC. Alcoa is required to submit its final decommissioning plan to the government at least 6 months prior to closure of the refinery.

Guiding Principle: Closure Provision
Alcoa to continue to build the closure provision to cover the cost of future rehabilitation, closure and ongoing post closure management.

Alcoa’s Response
Alcoa recognises its liability for rehabilitation of the residue areas and will continue to maintain a financial provision for this rehabilitation.
10.1 Summary of Guiding Principles and Alcoa’s Response

The Wagerup LTRMS has been significantly influenced by input from the community, via the SRG process. As reflected throughout this document, the SRG participated in extensive discussion of residue management and planning issues, enabling them to develop informed guiding principles for consideration by Alcoa.

Alcoa accepts and agrees with this principle.

Alcoa accepts and agrees with this principle.

Alcoa to use social media (where appropriate) and other communication methods easily accessible by the local community and other stakeholders to communicate progress on the LTRMS.

Alcoa is committed to keeping the local community and other stakeholders informed about the progress of the LTRMS and the Guiding Principles. Alcoa considers the Alcoa website and CCN forums to be the most appropriate methods to ensure that this information is easily accessible; however social media and other communications methods will continue to be assessed.

Table 10-1 summarises the guiding principles developed by the SRG and Alcoa’s response to each principle.

These guiding principles are discussed further in the body of this document, together with the information discussed on each of the issues to which they relate. The guiding principles will be reviewed and updated during the next review of the LTRMS by future SRG.

Table 10-1: Stakeholder Reference Group Guiding Principles and Alcoa’s Response.

<table>
<thead>
<tr>
<th>Guiding Principle</th>
<th>Alcoa’s Response</th>
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<tbody>
<tr>
<td><strong>REPORTING ON PROGRESS OF GUIDING PRINCIPLES</strong></td>
<td></td>
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<tr>
<td>Alcoa to provide an annual report on progress against the Guiding Principles to the Wagerup CCN. The updates to be provided every 12 months from the date of Ministerial endorsement of the 2012 Wagerup LTRMS.</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td>Alcoa to document the feedback received from the annual reports for consideration in the development of the next Wagerup LTRMS.</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td>Alcoa to use social media (where appropriate) and other communication methods easily accessible by the local community and other stakeholders to communicate progress on the LTRMS.</td>
<td>Alcoa is committed to keeping the local community and other stakeholders informed about the progress of the LTRMS and the Guiding Principles. Alcoa considers the Alcoa website and CCN forums to be the most appropriate methods to ensure that this information is easily accessible; however social media and other communications methods will continue to be assessed.</td>
</tr>
<tr>
<td>Guiding Principle</td>
<td>Alcoa's Response</td>
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<tr>
<td><strong>RESIDUE REUSE</strong></td>
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<tr>
<td>Alcoa to urgently pursue all necessary approvals for the use and commercial production of Red Sand™.</td>
<td>Alcoa accepts and agrees with this principle. Seeking approval for the use and commercial production of Red Sand™ is a key objective for Alcoa, however various factors including economic, operational, and regulatory impacts may impede progress of this action.</td>
</tr>
<tr>
<td>Alcoa to identify sustainable markets for the use of Red Sand™, including business modelling to identify sources and location of demand.</td>
<td>Alcoa accepts and agrees with this principle. Seeking approval for the use and commercial production of Red Sand™ is a key objective for Alcoa, however various factors including economic, operational, and regulatory impacts may impede progress of this action.</td>
</tr>
<tr>
<td>Alcoa to continue to undertake further research and identify other opportunities for the use of red mud (Alkaloam®).</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td><strong>DUST MANAGEMENT</strong></td>
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<tr>
<td>Review the current dust management system (including the sprinkler system and weather forecasting data) to identify and implement areas for improvement to contain dust within the residue areas.</td>
<td>Alcoa accepts and agrees with this principle. As part of the environmental management system, Alcoa regularly reviews its dust management processes and practices with the objective of continuously improving dust containment at the residue areas. Since 2007, Alcoa made further significant improvements to its dust management processes and Alcoa will continue to monitor the effectiveness of these changes and make further improvements as necessary.</td>
</tr>
<tr>
<td>Communicate dust management improvements and results from dust investigations to the CCN, SRG and surrounding community members in a timely manner.</td>
<td>Alcoa will communicate dust management improvements and relevant learnings from dust investigations at least annually to the CCN and to surrounding community members.</td>
</tr>
<tr>
<td><strong>RESIDUE ODOUR AND VOC EMISSIONS</strong></td>
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<tr>
<td>Alcoa to identify odour characteristics and implement mitigation strategies to reduce odour and VOC emissions.</td>
<td>The Alumina Industry Air Emission Forum (AIAEF) is currently considering a proposal to conduct research into the odorants that create the “wet cement” odour associated with the Bayer Process (the process Alcoa utilises in its refineries to produce alumina). Alcoa is a member of the AIAEF and supports this research proposal.</td>
</tr>
<tr>
<td>Communicate outcomes of research into odour and VOC emissions, and provide information on odour and VOC emission mitigation strategies to the community via avenues such as the CCN.</td>
<td>Alcoa accepts and agrees with this principle. Alcoa will communicate information and outcomes of research on odour and VOC emissions subject to commercial confidentiality considerations.</td>
</tr>
<tr>
<td>Guiding Principle</td>
<td>Alcoa’s Response</td>
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<tr>
<td><strong>RESIDUE ODOUR AND VOC EMISSIONS</strong></td>
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<tr>
<td>Continue to monitor employee’s health and wellness changes as an indicator of broader community health, and provide ongoing reports to the local community.</td>
<td>Alcoa accepts and agrees with this principle. Healthwise is a long-term research program designed to assess whether there are any relationships between various health outcomes and working at Alcoa in Australia. Alcoa has participated in the Healthwise research program since 1994 and it is one of the largest and most comprehensive occupational health research programs carried out in Australia. The studies are conducted by some of Australia’s leading occupational health researchers from Monash University and The University of Western Australia. Alcoa will report on the outcomes from the research to the local community and other stakeholders.</td>
</tr>
<tr>
<td><strong>OXALATE MANAGEMENT</strong></td>
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<tr>
<td>Alcoa to set the maximum achievable target for oxalate recovery within 12 months of the implementation of the Bio-oxalate removal plant, in consultation with the local community. Alcoa to develop and implement a program to achieve this target, with timelines communicated to the community. This target will be based on current storage levels and removal capacity.</td>
<td>Alcoa is currently assessing oxalate recovery and destruction capability at Wagerup. Once the capability is determined, Alcoa will consult with the local community prior to establishing the oxalate recovery target, and implement a program to achieve this target.</td>
</tr>
<tr>
<td><strong>WATER USE</strong></td>
<td></td>
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<tr>
<td>Alcoa to continue to focus on water efficiency by maximising water conservation and the use of recycled and fit for purpose water.</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td><strong>GROUNDWATER</strong></td>
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<tr>
<td>Alcoa to continue regular and systematic surface and groundwater monitoring in and around the RSAs based on Alcoa’s environmental licence conditions.</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td>Alcoa to commit to action for remediation of any known leaks to prevent migration of contamination from the RSA footprint.</td>
<td>Alcoa is committed to continuing its extensive groundwater monitoring and management strategy and where appropriate will implement remedial actions for identified leaks.</td>
</tr>
<tr>
<td>Guiding Principle</td>
<td>Alcoa's Response</td>
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<tr>
<td><strong>VISUAL AMENITY</strong></td>
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<tr>
<td>Alcoa to regularly update the visual amenity plan to create a natural looking landscape. This plan should focus on identifying and developing strategies to enhance visual amenity at current and future visual amenity “hot spots” (including the South Western Hwy) and the maintenance of any established vegetation buffers. As part of this planning process, Alcoa should provide assistance to landholders to establish screening where appropriate.</td>
<td>Alcoa accepts and agrees with this principle. Alcoa will continue to develop and regularly update a visual amenity plan that will include progressive embankment rehabilitation and visual screening to make the residue areas appear as natural looking landscape as possible.</td>
</tr>
<tr>
<td>Alcoa to develop and implement a strategy to mitigate unnecessary light emissions from the residue area whilst maintaining a safe work environment. This strategy should include informing the local community how they can provide feedback on light emissions.</td>
<td>Alcoa accepts and agrees with this principle. Alcoa needs to maintain a safe working environment for its employees however we invite feedback on light emissions that are an issue for our neighbours.</td>
</tr>
<tr>
<td><strong>RESIDUE REHABILITATION</strong></td>
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<tr>
<td>Alcoa to continue to improve its residue rehabilitation prescription with a focus on developing a self-sustaining ecosystem that maximises the use of endemic plant species wherever possible.</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td>Alcoa to study the effect of fire on the residue rehabilitation and apply the outcomes of this work to improve the rehabilitation’s resilience to fire impacts.</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td>Alcoa to investigate options to reduce the time between the completion of civil works and the commencement of rehabilitation.</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td><strong>ALTERNATIVE RESIDUE STORAGE TECHNIQUES</strong></td>
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<tr>
<td>Alcoa to actively pursue alternative residue storage and reuse technologies with the objective of reducing the required residue area, and trial these technologies at Wagerup wherever possible.</td>
<td>Alcoa accepts and agrees with this principle. Alcoa considers a number of factors when selecting a site to trial new technology and processes. These factors include the location of suppliers or customers and compatibility with current processes. Where trials of new technology and processes prove successful, Alcoa's aim is to implement the proven technology or process improvements wherever feasible.</td>
</tr>
<tr>
<td>Guiding Principle</td>
<td>Alcoa’s Response</td>
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</table>
| **SEPARATION DISTANCE**                                                          | Alcoa is committed to the current Land Management Strategy and will endeavour to maximize the separation distance to private residences. It must be noted that the extent of the midterm drying area footprint is a function of a number of variables including:  
  • The height that the residue stacks are built to;  
  • The production rate and commissioning timeframe for the expanded refinery;  
  • The possible need to realign the Alinta owned power lines along Kubank Road;  
  • The requirement to maintain an adequate separation distance to near neighbours;  
  • Zoning approval for the 25 year footprint; and  
  • Ownership of land, and hence  
    » Separation achieved to near neighbours, and  
    » Land available for residue storage.                                                                                                                   |
| Alcoa to maintain a 2 km separation distance between the boundary of the residue area and private property and/or residences. |                                                                                                                                                                                                                                                                                                                                                 |
| Alcoa to make a genuine effort to negotiate the purchase of whole properties from neighbours within 2 km of the boundary of the residue area who wish to move. | Alcoa will continue to implement the existing Land Management Strategy.                                                                                                                                                                                                                                                                         |
| Alcoa has defined an area as part of its Land Management Strategy known as Area A. Area A allows for future expansion of the residue area to the west and is based on the 35 dB(A) noise contour to the north and south. |                                                                                                                                                                                                                                                                                                                                                 |
| **FOOTPRINT AND HEIGHT**                                                          | Alcoa acknowledges that the Stakeholder Reference Group would like to see a residue reuse program implemented, and improvements in visual amenity, dust management and residue rehabilitation. Alcoa is committed to continuing to evaluate a residue reuse program and improvements in these environmental aspects.                                                                                     |
| The Stakeholder Reference Group recommends that residue expansion into the future will be in a westerly direction at 40 metres above natural ground level, but Alcoa needs to: | During the 2007 LTRMS review, in response to the feedback received from the 2007 Wagerup LTRMS Working Group, Alcoa committed to not increase the height of the residue stack above 40 metres above natural ground level before 2012. Alcoa fulfilled this 2007 commitment, and the current height of the residue area is 29 metres above natural ground level (43 metres RL). Alcoa also committed at that time that the midterm residue footprint plans would be developed on a reduced height of 60 metres above natural ground level (74 metres RL) as this will produce the most sustainable outcomes (Alcoa’s other WA sites have 25 year life-of-mine footprints based on residue heights of 80 metres).  
Alcoa also committed that at time that the midterm residue footprint plans would be developed on a reduced height of 60 metres above natural ground level (74 metres RL) as this will produce the most sustainable outcomes (Alcoa’s other WA sites have 25 year life-of-mine footprints based on residue heights of 80 metres).  
As a result of these forward plans, in the coming 5 year period (to 2017) Alcoa will build part of the residue area up to a height of approximately 45 metres above the natural ground level (59 metres RL). In this coming five years, the area planned to be developed up to this height will be a maximum of 10 hectares. |
| • Implement a residue reuse program as a matter of urgency (as per the Residue Reuse Guiding Principles);  
• Improve visual amenity (as per the Visual Amenity Guiding Principles);  
• Improve dust management (as per the Dust Management Guiding Principles); and  
• Improve outer bank revegetation (as per the Visual Amenity and Residue Rehabilitation Guiding Principles). |                                                                                                                                                                                                                                                                                                                                                 |
Guiding Principle | Alcoa’s Response
---|---
The additional drying area that this will provide will ensure that the refinery has sufficient residue storage area, the mud has sufficient time to dry to the required strength, and that there is sufficient water storage capacity within the residue area.

Alcoa has reviewed its medium term (25 years) plans, taking into consideration the input of the 2012 Wagerup LTRMS SRG. As a result of this review, Alcoa has resolved to continue developing the residue stack to 60 metres above natural ground level (74 metres RL) as this will be the most sustainable option in terms of environmental, social and economic outcomes, and is in line with a number of other guiding principles developed by the Stakeholder Reference Group, such as:

- **Residue Odour and VOC Emissions** – An increased stack height will result in a reduced surface area from which odour and VOC emissions can potentially be produced;
- **Groundwater** – An increased stack height reduces the residue footprint and reduces the potential for groundwater contamination;
- **Separation Distance** – An increased stack height will allow Alcoa to maximise the separation distance between the residue stacks and privately owned property; and
- **Closure** – An increased stack height reduces the footprint of land occupied by residue at closure, and reduces the surface area that will capture water that will require treatment and disposal post closure of the residue areas.

Alcoa acknowledges the stakeholder feedback received during the 2007 and 2012 reviews of the LTRMS and understands the desire for Alcoa to work towards the residue drying area not exceeding 40 metres above natural ground level.

Alcoa continues to investigate alternative residue storage technologies and residue reuse initiatives with the objective of reducing the area required for residue storage in the future. However, until any alternative technology or process is proven and is assessed as being economically viable, Alcoa’s forward planning must be based on the current technology and processes.

Continual improvement of the visual amenity, dust management and residue rehabilitation programs remains a key focus for residue management and Alcoa will continue to keep the community informed of progress in these areas.
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<tr>
<th>Guiding Principle</th>
<th>Alcoa’s Response</th>
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<tr>
<td>CLOSURE</td>
<td><strong>Alcoa to investigate and pursue strategies to reduce the volume of water that will require treatment both during the life of the refinery and post closure.</strong> In considering any new technology or process, Alcoa evaluates a range of factors including implications for water management both during and post closure of the refinery. Alcoa is undertaking studies on the water balance of the residue areas with the aim of identifying opportunities to modify the residue rehabilitation prescription and embankment design to reduce volume of drainage water requiring ongoing management. While the refinery is operating, all water collected from the residue area is recycled to the refinery for reuse, and the residue area is a significant water source for the refinery. Alcoa will continue to undertake these further investigations to identify and investigate possible options for post closure water management between now and closure of the refinery.</td>
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<td><strong>Alcoa to further investigate options for water treatment and discharge post closure of the refinery.</strong> Alcoa accepts and agrees with this principle. The process of defining the closure strategy will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes may change. The current LTRMS review will not be able to identify the appropriate final strategy for post closure water management but will identify the need for further investigations to occur. Alcoa will continue to undertake these further investigations to identify and investigate possible options for post closure water management between now and closure of the refinery.</td>
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<td></td>
<td><strong>Alcoa to continue to improve residue management to maximise the options for final land use and land form.</strong> Alcoa accepts and agrees with this principle.</td>
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<td><strong>Alcoa to develop an adequate closure management plan to ensure the local community is not left with a legacy of adverse impacts after the refinery is closed.</strong> Alcoa accepts and agrees with this principle. In accordance with conditions of Ministerial Statement No 728, Alcoa has submitted a preliminary decommissioning plan to the DEC. Alcoa is required to submit its final decommissioning plan to the government at least 6 months prior to closure of the refinery.</td>
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<td></td>
<td><strong>Alcoa to continue to build the closure provision to cover the cost of future rehabilitation, closure and ongoing post closure management.</strong> Alcoa recognises its liability for rehabilitation of the residue areas and will continue to maintain a financial provision for this rehabilitation.</td>
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## Document history and status

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<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
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<td>Reduced Level. A surveying term which means a height above (or below) a datum. In Australia, this datum is called the “Australian Height Datum” (A.H.D.) and is calculated from the average of many tide gauges.</td>
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<td>Volatile Organic Compound</td>
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<td>Water Authority of Western Australia</td>
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Australia, October 2008.


