Long Term Residue Management Strategy

Kwinana 2012
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Executive Summary

Introduction
The Kwinana Long Term Residue Management Strategy (LTRMS) was initially developed in response to a voluntary commitment 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 third published strategy for Alcoa’s Kwinana 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 during a six month period. The majority of the document’s content reflects presentations to and outcomes from, the Stakeholder Reference Group (SRG) 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 Kwinana 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 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 Kwinana 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 Kwinana 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 SRG 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 this 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 SRG’s deliberations has been provided in the form of 39 guiding principles to Alcoa for consideration in the development of the LTRMS. These were developed for environmental and social issues considered particularly significant by the group, and include:

- community education on residue management;
- residue reuse;
- flora, fauna and land management;
- heritage management;
- hydrology;
- dust control and management;
- odour management;
- the relationship between residue and health issues;
- current or potential groundwater contamination management;
- Residue Storage Area (RSA) footprint, height and footprint reduction opportunities;
- compatible land use planning;
- visual amenity;
- residue closure and rehabilitation; and
- community reporting.
These guiding principles, together with Alcoa’s responses, are 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 single greatest factor affecting the final footprint of the residue area is the stack design. Specifically the height to which the stack can be constructed, while providing the required open area for drying, defines the minimum residue footprint that can be achieved.

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

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 LTRMS SRG process.

Constraints on Forward Planning
Despite the level of effort which goes into forward planning, 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.

The plans presented in this 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 five to seven year plan presented in this document, additional consultation may be required.

Short-Term Construction Strategy
Key issues to be managed within the five year time frame are maintenance of:
- residue storage and drying capacity to meet the requirements of the refinery, and
- water storage, surge capacity, cooling and process water supply functions for the refinery.

During the period 2012-2019 Alcoa currently plans to meet residue storage requirements for current production rates through construction of two new greenfield drying areas. Area O and Area P are planned to be constructed within the Rural B zoned area to the west of the current residue area, providing approximately 60 hectares of new drying area. The locations of these future drying areas are shown in Figure ES-1.

As part of Alcoa’s mid-term residue construction strategy, Alcoa plans to convert the existing wet storage Area H to dry stacking. Alcoa is currently...
investigating an option to bring forward these plans by converting part of the existing Area H to dry stacking in the short-term. A partial conversion of this wet storage area to dry stacking will result in the environmental benefits of this conversion being realised earlier, and will also provide an opportunity for Alcoa to complete the feasibility assessment for press filtration and potentially implement this new technology ahead of the next greenfield residue development.

The storm surge storage capacity design that is included in the Area O project includes capacity to contain storm surge from the existing Area N, once the embankments on Area N are lifted. The Area N embankment lift is currently planned for 2013. Due to the delays that have been experienced with the Area O project, this additional storm surge storage will not be available in time to meet the storm surge storage requirements of Area N once the embankment lift is completed.

Alcoa is currently considering options to meet the future Area N storm surge requirements, and the most likely option currently under consideration is the development of a new surge pond in the corner of the existing Area N footprint. The conversion of the corner of Area N from residue storage area to surge pond would result in a small loss of residue storage area within Area N, but would provide a surge pond that can be used indefinitely for storm surge storage. If Alcoa proceeds with this option, it is currently envisaged that construction of this surge pond will commence in 2013. The pond will be completely contained within the original dam constructed for Area N.

As outlined in the 2005 Kwinana LTRMS document, Alcoa is currently implementing plans to close and rehabilitate Area F. To date, significant progress has been made to cap and rehabilitate the area; currently, only 19% of the original drying area remains open.

For the remainder of Area F to be closed, Area O and its associated Runoff Collection Pond (ROCP) must be constructed and commissioned to ensure the required drying area for Kwinana Refinery. The Area O project has been in development for a number of years, and to date, significant progress has been made in gaining the necessary approvals. At the time of publication, Area O is expected to be commissioned at the end of 2015, and the ROCP in 2016. The process to close the remainder of Residue Storage Area F will commence once these areas are commissioned.
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:

- conversion of the existing wet storage Area H to dry stacking;
- relocation of the super-thickener and associated infrastructure, and conversion of the area to dry storage;
- construction of new water storage facilities to replace the existing Run Off Water Storage (ROWS) Pond and water storage function of the existing Area H;
- conversion of the existing ROWS pond to residue storage, providing approximately 20 Hectares of drying area; and
- relocation of infrastructure, as required, to support the above projects.

The locations of these future drying areas are shown in Figure ES-1.

Figure ES-1: Proposed locations for future residue facilities.
Life-of-Mine Strategy
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). As long as timely acquisition and rezoning of land can be achieved for the new water storage facilities outlined in the mid-term construction strategy, Alcoa currently has sufficient appropriately zoned land to provide residue area for the life of the refinery, at current planned production rates and the known bauxite reserve within Mineral Lease 1SA. 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.

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 RPLG 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 Kwinana LTRMS SRG members who provided a considerable amount of personal time and commitment in working with Alcoa during 2011 to produce this LTRMS for the Kwinana 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 Kwinana Alumina Refinery is situated 40 kilometres south of Perth in the Kwinana Industrial Area – Western Australia’s premier heavy industrial estate.

The Kwinana Refinery was officially opened in July 1963 with production beginning three months later. It has a capacity of 2.15 million tonnes of alumina per year and produces smelter grade alumina and a variety of specialty aluminas which have a wide range of industrial and manufacturing applications such as water purification, refractory materials, pharmaceuticals, artificial marble, paper sizing, ceramics, abrasives, petroleum processing, plastic and fire retardants in carpets.

Bauxite is supplied to the refinery from Alcoa’s Huntly bauxite mine, located 25 kilometres east of the Pinjarra Refinery. The bauxite is transported by conveyor to the Pinjarra Refinery and then railed 90 kilometres to Kwinana for refining. The bauxite is low grade by world standards, requiring approximately three tonnes of bauxite to produce one tonne of alumina. The material remaining after alumina has been extracted from the bauxite ore is commonly termed ‘residue’.

Alumina produced at the Kwinana Refinery is shipped from the Kwinana shipping terminal and is exported to overseas markets or to Alcoa’s aluminium smelters in Victoria.

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 Kwinana Refinery’s LTRMS 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 six 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 Kwinana Refinery 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 Kwinana Refinery operates.

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

Section 7: Environmental management strategies for residue storage and changes in management since the last LTRMS review.

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 developed through the Kwinana LTRMS SRG process.
Figure 1-1: Location map.
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.

In August 1995 an expansion of the Wagerup Refinery was authorised by the Minister for the Environment. The Minister’s statement (Number 390) replaced the earlier 1989 Ministerial conditions with expanded and clarified conditions related to long term residue management.
Residue management was expanded to engage the local community and stakeholders directly in the planning process for the first time. This aimed to ensure that the concerns and queries of the local community, local government and regulatory authorities, and Alcoa’s response to these issues, were transparent and clearly documented. This was achieved by utilising an SRG. The role of the SRG was “To assist Alcoa in developing a long term strategy for bauxite residue management at the Kwinana Refinery by providing opinions and feedback on issues raised and, where applicable, provide Guiding Principles for the company to consider in the development of the Long Term Residue Management Strategy (LTRMS).”

Although no such conditions have been set for the Kwinana Refinery, Alcoa has voluntarily committed to meeting these conditions for the Kwinana operations.

The Kwinana Refinery LTRMS was first produced in 1998 to enable Alcoa to demonstrate sound environmental management of the residue area to the government and the community. The LTRMS accounted for the views of a wide group of stakeholders and interested parties and focused on demonstrating compliance with legal and corporate requirements and detailing the engineering elements of residue planning.

2.2 2005 LTRMS Review
Alcoa initiated a review of the 1998 Kwinana Refinery LTRMS in April 2004. During this review the approach to residue management was expanded to engage the local community and stakeholders directly in the planning process for the first time. This aimed to ensure that the concerns and queries of the local community, local government and regulatory authorities, and Alcoa’s response to these issues, were transparent and clearly documented.

This was achieved by utilising an SRG. The role of the SRG was “To assist Alcoa in developing a long term strategy for bauxite residue management at the Kwinana Refinery by providing opinions and feedback on issues raised and, where applicable, provide Guiding Principles for the company to consider in the development of the Long Term Residue Management Strategy (LTRMS).”

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.
Following the 2005 LTRMS review, a further expansion of the Wagerup Refinery was authorised by the Minister for the Environment in September 2006. The Ministerial Statement (Number 728) replaced the earlier 1995 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);
- periodically review the long term management plans for the residue deposit in consultation with the RPLG and community stakeholders;
- address the potential impacts of emissions from the residue areas in consultation with the RPLG, in particular the management of emissions and protection of groundwater;
- have the LTRMS independently reviewed to review the monitoring and management against best practice (through the RLP3);
- make the LTRMS publicly available; and
- implement the actions and practices identified in the LTRMS.

Although no such conditions have been set for the Kwinana Refinery, Alcoa has voluntarily committed to meeting these conditions for the Kwinana operations.

### 2.3 2012 LTRMS Review

This current review of the LTRMS commenced in 2011 and repeated the previous successful use of an SRG to obtain advice and feedback on strategy options from local community, local government and regulatory authorities. The 2011 LTRMS SRG review addressed residue infrastructure requirements for the life of the mine (2045) as well as the 25 year footprint requirements and the 5-7 year development plan. 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.

### 2.4 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 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 net 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.

### 2.5 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...
Kwinana Refinery long term residue management strategy

(EIPs). After Alcoa chose to produce an EIP for its Kwinana Refinery in 2005, a decision was made to transform the CCN into an EIP Advisory Group to provide guidance in the development of Kwinana Refinery’s EIP. The Kwinana CCN nominated and agreed on the community membership of that group.

2.5.2 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.

Kwinana 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.

Kwinana Refinery’s EIPs are developed by an EIP Advisory Group, a consultative group made up of representatives from the local community, Local and State Government, environmental regulators and Alcoa. The aim of the group is to establish targets for environmental improvement and subsequently devise actions to achieve those targets.

The EIPs cover areas such as:

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

In 2009, Alcoa reviewed the timeframes of EIPs across its WA operations and decided to move to three year EIPs. The 2011-13 EIP was developed in late 2010.

For 10 years the CCN provided Alcoa’s Kwinana Refinery with vital community feedback and input on a range of issues and activities of mutual interest in a number of areas.

Membership of the CCN was open to the local community in a voluntary capacity with most areas of interest for the community focusing on Kwinana’s environment performances.

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 Kwinana Refinery in 2005, a decision was made to transform the CCN into an EIP Advisory Group to provide guidance in the development of Kwinana Refinery’s EIP. The Kwinana CCN nominated and agreed on the community membership of that group.

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2.5.3 Community and Industries Forum (CIF)
As a member of the Kwinana Industries Council (KIC), Alcoa participates in the Community and Industries Forum (CIF). CIF operates a public, advertised community forum directed by an executive committee. The committee membership is drawn from interested community members, State regulators, and the KIC members. Meetings are held quarterly and provide an open forum to exchange information between community, industry, and regulators.

2.6 Kwinana LTRMS Stakeholder Reference Group
In the past, Alcoa’s residue planning has largely been an internal process with feedback incorporated from government agencies.

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 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 Kwinana 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.

<table>
<thead>
<tr>
<th>Affiliation</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land Holders</strong></td>
<td></td>
</tr>
<tr>
<td>Local Resident</td>
<td>Ray Lees</td>
</tr>
<tr>
<td>Local Resident</td>
<td>Jenny Swift</td>
</tr>
<tr>
<td>Local Resident</td>
<td>Sam Mahesan</td>
</tr>
<tr>
<td>QUBE Property Group</td>
<td>Rhys Kelly</td>
</tr>
<tr>
<td><strong>Local Government</strong></td>
<td></td>
</tr>
<tr>
<td>City of Cockburn</td>
<td>Cr Carol Reeve-Fowkes</td>
</tr>
<tr>
<td>City of Kwinana</td>
<td>Cr Merv Kearney Ms Jacelyn Drummond</td>
</tr>
<tr>
<td><strong>State Government</strong></td>
<td></td>
</tr>
<tr>
<td>Department of Environment and Conservation</td>
<td>Lauren Trott</td>
</tr>
<tr>
<td>Department of State Development</td>
<td>Phil Knight</td>
</tr>
<tr>
<td>Department of Planning</td>
<td>Andrew Trevor</td>
</tr>
<tr>
<td>Department of Health</td>
<td>Lindsay Gillam</td>
</tr>
<tr>
<td><strong>Business</strong></td>
<td></td>
</tr>
<tr>
<td>Perth Motorplex</td>
<td>Kevin Prendergast</td>
</tr>
<tr>
<td><strong>Alcoa</strong></td>
<td></td>
</tr>
<tr>
<td>WA Operations Residue Environmental Manager</td>
<td>Anika Wall</td>
</tr>
<tr>
<td>WA Residue Operations and Maintenance Manager</td>
<td>Matthew Cox</td>
</tr>
<tr>
<td><strong>Independent Facilitator</strong></td>
<td></td>
</tr>
<tr>
<td>ikon</td>
<td>Ron Kemp (First Meeting Only)</td>
</tr>
<tr>
<td>Andrew Huffer and Associates</td>
<td>Andrew Huffer (Meetings 2-7)</td>
</tr>
</tbody>
</table>

Table 2-1: Kwinana LTRMS Stakeholder Reference Group membership.

The framework for stakeholder consultation in the LTRMS review for Kwinana Refinery is presented schematically in Figure 2-2.

2.6.1 Formation of the Kwinana LTRMS Stakeholder Reference Group
The Kwinana LTRMS SRG was formed in February 2011 and met regularly from August 2011 until December 2011. The process used to establish the SRG is outlined below.

2.6.1.1 Landholder Representation
To ensure adequate representation by landholders on the SRG, a letter was hand delivered to local residents in January 2011, inviting them to participate in the review of the LTRMS as a member of the SRG.
Meeting reports were produced by WA Operations Residue Administration Assistant, Kerry Black, and Kwinana Refinery Community Relations Officer, Rod Mapstone.

### 2.6.2 Stakeholder Reference Group Terms of Reference and Operating Procedures

An independent facilitator, Ron Kemp, was initially appointed to the SRG. Due to delays in the process, Ron was unable to continue as the group’s facilitator after the first meeting, and Andrew Huffer was subsequently appointed to the SRG for the remainder of the process. 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.

Advertisements were also placed in local papers inviting near neighbours, local business owners and those with a special interest in the environment to participate.

Following the delivery of letters and advertisements in the local papers, two information forums were held for those interested in participating in the review process. The forums outlined the process for developing the LTRMS as well as the Terms of Reference and expectations of those wishing to participate. At the conclusion of the forum, attendees were invited to nominate to become a member of the SRG.

All local residents who expressed an interest joined the group. The group formed included four local residents. Unfortunately one of the SRG’s local residents resigned from the group early in the process due to changes in personal circumstances. Two property development companies also nominated, and one of these nominations was appointed to the SRG. The other property development nominee, Ray Stokes from Satterley Property Group, attended several of the meetings as an observer.

During the consultation process, other neighbours and land holders who have expressed an interest in the process were invited to attend as observers or participants.

#### 2.6.1.2 Local Business Representation

A nomination was received and accepted from one local business, Perth Motorplex.

#### 2.6.1.3 Government Representation

Local and State government representation was sought and received from the City of Kwinana, City of Cockburn, Department of Environment and Conservation, Department of State Development, Department of Planning and Department of Health.

#### 2.6.1.4 Alcoa Representation

Alcoa was represented on the LTRMS by its WA Residue Operations and Maintenance Manager, Matthew Cox, and WA Residue Operations Environmental Manager, Anika Wall. David Honey, WA Residue Manager, attended all of the meetings as an observer.

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Table 2-2 contains the actual meeting schedule and issues addressed by the group.

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### Table 2-2: LTRMS Stakeholder Reference Group meeting schedule.

<table>
<thead>
<tr>
<th>Meeting No.</th>
<th>Date</th>
<th>Topics Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 Feb 2011</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>9 Aug 2011</td>
<td>Environmental management – Part 1</td>
</tr>
<tr>
<td>3</td>
<td>16 Aug 2011</td>
<td>Environmental management – Part 2</td>
</tr>
<tr>
<td>4</td>
<td>13 Sep 2011</td>
<td>Land management – planning schemes, legislation and compatible land use health considerations</td>
</tr>
<tr>
<td>5</td>
<td>8 Nov 2011</td>
<td>Residue storage requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Factors affecting storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Criteria for selecting sustainable options</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Residue storage scenarios</td>
</tr>
<tr>
<td>6</td>
<td>15 Nov 2011</td>
<td>Final land use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Finalise guiding principles</td>
</tr>
<tr>
<td>7</td>
<td>13 Dec 2011</td>
<td>Alcoa’s response to guiding principles</td>
</tr>
</tbody>
</table>
Kwinana 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.

2.6.4 Consultation Guiding Principles and Alcoa’s Commitments

In response to the information provided, the Kwinana LTRMS SRG developed two 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 report at least annually on its progress against the “Guiding Principles” developed by the 2011 Kwinana LTRMS SRG.

Alcoa’s Response

Alcoa accepts and agrees with this principle.

Guiding Principle: Education

Alcoa shall implement processes that assist in educating the community about the improvements that have been achieved and about the practicalities of alumina refining, and bauxite residue management.

Alcoa’s Response

This recommendation falls outside of the scope of the LTRMS, however Alcoa will forward this advice to the CCN to discuss and resolve an appropriate response.
3 aluminia refining process

3.1 Overview
The Kwinana 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 Residue Storage Areas (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.

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 pumped 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 backup 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 areas near the refinery.

Residue consists of a coarse sand fraction (often termed ‘red sand’) and a fine silt fraction (often termed ‘red mud’). The mud and sand streams are pumped together to the residue area and separated.
in the sand separation building located at the residue area. Approximately 55% of the residue stream is sand and 45% is mud. The mud density is increased at the residue area by thickening prior to its final discharge into RSAs. The sand is stockpiled and subsequently used for internal construction activities at the residue storage area. Oxalate, another process by-product, is also stored in approved areas on site.

A number of other facilities that support the refining operations are located in the residue area. These include ponds to cool refinery process liquor (Cooling Pond) and to store rainfall run-off water from both the refinery site and residue area (ROWS pond). The ROWS pond is designed to contain the accumulated run-off from a 1:100 wet year. Water is recycled back to the refinery via the cooling and lake water ponds.

3.8 Refinery Water Circuit

The Kwinana Refinery currently uses 3.49 kilolitres of water per tonne of alumina product (annualised figure). 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 residue area 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.
4.1 Overview

Early bauxite residue management processes involved the deposition of residue mud as dilute slurry into storage areas – termed ‘wet’ disposal. In 1987, Kwinana 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.

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 Kwinana, including water storage facilities, was 543 hectares and the maximum residue height was around RL 78 metres. Residue area 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 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 Chapter 3, 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. See Section 4.6.3 for details. Carbonation of the residue significantly reduces the potential environmental impacts from residue.

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 (greater than 150 µm) 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 (less than 150 µm) 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 (known as the super-thickener) 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 is mechanically turned over using bulldozers and amphibols. 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 storage capacity 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.

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.
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

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” (Department of Industry, Tourism and Resources, 2007) 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.

Figure 4-1 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 hydrogeological 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.

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.
compacted clay with a hydraulic conductivity of less than $10^{-4}$ metres per second, 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 area 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 facilities are constructed in accordance with the approved design drawings and specifications, and in accordance with a quality assurance plan which meets ISO 9000 standards. At the completion of construction of a new residue facility, a project completion report is prepared which documents quality control results, site conditions and modifications to specifications and design drawings to reflect ‘as built’ conditions. Subsequent lifting of embankment walls is subject to similar vigorous design criteria as the initial residue area. This ensures stability both during construction and in the long term. The ultimate ability of the overall residue stack to be self-supporting is periodically verified through density analysis and computer generated stability models that consider a range of loadings. 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 undertaken 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 owned property south of the current residue footprint and borrow areas are rehabilitated when the resource is exhausted.

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, 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®) have been identified as the best opportunity for high volume uses.

4.6.2.1 ReadyGrit®

Alcoa’s residue sand is currently used for the construction of residue areas, with excess being stored within the RSAs. Alcoa has developed a process to wash and carbonate the sand so that it can be considered for use as a building material. The resulting product is known as ReadyGrit®. ReadyGrit® has a nominal particle size of +100 microns ($\mu$m) and is physically...
similar to crushed bauxite. In Alcoa’s Western Australian refineries, red sand constitutes up to half of the residue going to the residue area.

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 Western Australian Department of Environment and Conservation (DEC) has responded positively to a submission seeking support for the use of the sand for the proposed applications. The DEC required a risk assessment to be conducted to confirm that ReadyGrit® produced from Kwinana residue will not exceed the Ecological Impact Limits set by the DEC.

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 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 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 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. Kwinana’s carbonation plant is illustrated in Figure 4-3.

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

**Guiding Principle: Alternative Uses**
Alcoa to continue actively pursuing safe alternative uses of residue.

**Alcoa’s Response**
Alcoa will continue to pursue safe alternative uses of residue. Each potential use will be assessed for feasibility on a case-by-case basis.

**Guiding Principle: Research**
Alcoa to utilise existing residue reuse trial sites for monitoring and evaluation purposes.

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

**Guiding Principle: Education**
Alcoa to develop and implement an ongoing program to educate the general public about the safety and potential benefits of residue products.

**Alcoa’s Response**
Alcoa currently seeks relevant opportunities to educate stakeholders about the safety and potential benefits of residue products. This will be continued in the future.

**Guiding Principle: Product Approval**
Alcoa to document the approvals pathway that it follows for approval of residue reuse products, identifying barriers and success points for future learning and share the information as appropriate.

**Alcoa’s Response**
Where relevant, Alcoa will share the approvals process followed for residue reuse products, subject to commercial confidentiality considerations.

**Guiding Principle: Reporting**
Alcoa to report annually on the status of research into residue re-use, including the status of any approvals required for its use.

**Alcoa’s Response**
Alcoa accepts and agrees with this principle.
Kwinana Refinery is located 22 kilometres south of Perth at the northern end of the Kwinana Industrial Area. The residue facilities are located approximately four kilometres east of the refinery. Both the refinery and the residue area are situated within the City of Kwinana, and the Western Trade Coast. The City of Cockburn boundary is approximately one kilometre to the north of the residue area.
5.1 Description of the Local Community

5.1.1 Community Profile

Residential development in the City of Kwinana varies from relatively dense suburban development in the south west to semi rural properties in the north east. The closest residences to the residue area are located on Mandogalup Road.

The City of Kwinana has a population exceeding 30,000 people within 120 square kilometres. Forecasts indicate that this will reach 70,000 by 2030 (Town of Kwinana, 2011). Most people live in the suburbs of Medina, Orelia, Parmelia and Leda which are situated to the south of the residue area. Kwinana is considered a National Hyper Growth Area – developing at twice the rate of the national average. However, Kwinana is rated the most disadvantaged area in the Perth metropolitan area in The Index of Relative Socio-economic Advantage and Disadvantage (Australian Bureau of Statistics (ABS), 2008).

Whilst a high proportion of the City of Kwinana population is of working age (median age 32 years), and the full-time employment rate (62%) is similar to the State average (64%), unemployment in the area is high (6.7%) compared to the State average (3.0%). In the 2011 Census, the median weekly individual income in Kwinana was $606, compared with $662 for Western Australia. The median weekly household income was $1252, compared with $1415 in Western Australia (ABS, 2012). In relation to housing tenure, in 2011 69% of occupied private dwellings were owned or being purchased with approximately 28% being rented.

The City of Cockburn is located approximately one kilometre to the north of the residue area. The City of Cockburn has a much larger population than the City of Kwinana, with over 87,000 residents within 148.2 square kilometres. In 2011, the full-time employment rate of Cockburn residents was 42% and the unemployment rate was 3.0%. The median weekly individual income of Cockburn residents was $689, and the median weekly household income was $1540. In Cockburn, 74% of occupied private dwellings were owned or being purchased with approximately 24% being rented (ABS, 2012).

5.1.2 Economic Profile

The residue area is located within the Western Trade Coast which is an initiative between the Rockingham Kwinana Development Office, Departments of State Development, Environment & Conservation, Commerce, Planning, and Transport as well as Fremantle Ports, the Kwinana Industries Council, City of Cockburn, City of Kwinana and LandCorp. The Western Trade Coast includes the Rockingham Industrial Zone, Australian Marine Complex, Latitude 32 Industry Zone and the Kwinana Industrial Area (Landcorp 2012) and is one of Perth’s largest employment areas, contributing around $15.5 billion to the state’s economy.

Employment of City of Kwinana residents in the industrial sector has decreased significantly in recent years. In 2006, 38% of Kwinana residents were employed in the manufacturing industry, and 15% in the construction industry (ABS, 2007). This has reduced to 13% in the manufacturing industry and 11% in the construction industry in 2011 (ABS, 2012). Despite these decreases, employment in these industries is still significantly higher than for WA as a whole (8% and 1% respectively) (ABS, 2012).

5.2 Heritage

5.2.1 Aboriginal Heritage

Kwinana has one of the largest indigenous populations in the metropolitan area, with nearly 4% of the local population identifying as being of indigenous origin (ABS, 2012). Wetlands known as “The Spectacles” are located two kilometres south east of the residue area. These wetlands are of particular significance to the local Aboriginal community. In the 1970s, the Industrial Lands Development Authority and Alcoa purchased the land for future industrial use. However, when the land was evaluated for residue drying purposes it became clear that it had high conservation value and was worthy of protection. Since this time, Alcoa has worked closely with state government departments to ensure the Spectacles Wetland retains its high conservation value. Alcoa provides funding to the DEC for maintenance of The Spectacles.

Some of the relationships the Aboriginal people have with local ecosystems are displayed on a public Aboriginal walk trail around The Spectacles, developed by Alcoa in conjunction with local Aboriginal representatives and the then Department of Conservation and Land Management. In 2004, Alcoa sponsored the Spectacles Cultural Tours as part of the City of Kwinana’s 50th anniversary celebrations.

5.2.2 European Heritage

Kwinana’s history dates back to 1829 when the Swan River Colony was established. The first settlers were off-loaded from the transport ship Parmelia onto Garden Island after it ran aground, and were later taken to the mainland. The Kwinana district derives its name from the Steamship Kwinana. The Kwinana was originally the S.S. Darius and was bought in 1912 by the State Government. At first the ship was to be renamed Kimberley in 1912 by the State Government. At first the ship was to be renamed Kimberley
but there were too many ships of this name in Lloyds’ Register of Shipping. Kwinana was finally chosen. The name is a sub-division in the Kimberley district. It is aboriginal for Pretty Maiden (Town of Kwinana, 2011).

The first settlement of the region, known as Clarence, was situated at Woodman Point (8 kilometres to the northwest of the RSA). Thomas Peel brought three shiploads of settlers to the region in 1831, however they were unprepared for the conditions and the settlement failed within a few years.

In 1853, a convict outstation was established at Clarence. The 30 convicts stationed there levelled and upgraded what is now known as Rockingham Road through to Fremantle. In 1871 a small community began to grow in the area known as Hope Valley. From 1916 through to 1926 the area was called Huxtables, after the Navel Base Hotel licensee Mrs Serena Huxtable, however in 1927 the name returned again to Hope Valley. In 1962 the name Hope Valley became official at the suggestion of A.H. de San Miguel.

Four of the prominent families noted in the history of the Hope Valley area are: Postans, de San Miguel, Mortimer and Armstrong. Several descendants of these early settlers still live in the area and have strong ties to the history of the area.

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.

Kwinana Refinery has a workforce of more than 950 employees and 300 contractors. Around half of Kwinana Refinery’s employees live in the City of Kwinana or adjoining local government areas. In addition to those employed directly by Alcoa, the City of Kwinana benefits significantly from the indirect employment generated by Alcoa, through its engagement of local contractors and purchase of local products and services.

Alcoa encourages local suppliers to conduct business with the company. It invites local businesses to bid on locally supplied or manufactured goods or
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.

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 Kwinana 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 Kwinana Refinery is currently one of the world’s most efficient alumina refineries, accounting for approximately 2.3% of the world’s alumina (Alcoa, 2012).

5.3.3 Social Assessment Review
Stakeholder Perception Surveys are conducted every two years to help understand the expectations and perceptions held by key stakeholders across our operations.

The Stakeholder Perception Survey measures:
• Social licence to operate (social capital, interactional justice, procedural justice);
• Relationship satisfaction;
• Perceptions of performance (environmental, social, economic);
• Communication effectiveness;
• Awareness of issues and satisfaction with Alcoa’s handling of them; and
• Awareness of and performance of partnerships.

Key outcomes from the 2012 Kwinana survey revealed:
• The level of satisfaction with relationships with Alcoa personnel improved since 2010 (when the survey was last completed).

• Around one third of respondents indicated that their relationships with Alcoa are getting better.
• Respondents perceive Alcoa’s reputation to be improved when compared to 2010 results.
• Respondents believe the effectiveness of Alcoa’s communications have improved since 2010.

5.3.4 Partnerships and Volunteering
Kwinana 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 Kwinana Refinery currently has several key partnerships in each of these areas and also supports local community events. Some of these key partnerships are outlined below.

Challenger Beach Rehabilitation Project with Perth Natural Resource Management (NRM) and hosted by City of Kwinana
Focusing on conservation of the Challenger Beach Reserve, activities include planting and weeding, monitoring of fauna population, beach rubbish collection and coastal ecology education programs for local schools.

Castaways Sculpture Awards with City of Rockingham
An annual art exhibition which showcases local sculptors working with recycled and re-used materials. The exhibition is held along the Rockingham foreshore and Alcoa sponsors the category for the best artwork that uses aluminium as its primary component.

Lyrik Youth Leadership & Mentoring Program with City of Kwinana
Lyrik supports young people at risk of disengaging from their local community. It recognises and rewards community involvement and achievements, while developing leadership capability.

Alcoa Swim Schools with Kwinana Recquatic Centre
This partnership provides water safety programs and swimming lessons for children, adults and children with special needs.

Alcoa Cockburn Community Development Program with the City of Cockburn
The program aims to strengthen the capacity and resilience of community groups in the City of Cockburn. It supports and empowers local community groups to identify their needs and provides grants for events, community art projects, minor park infrastructure, volunteer initiatives and environmental projects.

Rockingham City Community Garden with the City of Rockingham
The Rockingham City Community Garden is planned and managed by the local community for the local community that, once established, will offer small lots to individuals, families and community groups, with produce being made available to local charities. Students undertaking horticultural studies and other trades are encouraged to participate.

Community Festivals
Alcoa provides financial support to annual festivals held in the local community, including Rockingham’s Musselfest, the Alcoa Kwinana Children’s Party and the Cockburn Spring Fair.

Employee Volunteers
Alcoa also provides support to Alcoa employees who volunteer with local community organisations. In 2011 around half of the workforce volunteered in their local communities, contributing in excess of 9,800 hours.
6.1 Climate
Kwinana has a Mediterranean type climate characterised by hot dry summers and cool wet winters.

6.1.1 Temperature and Humidity
The warmest months at Kwinana are January and February, when maximum temperatures average over 30 degrees and can exceed 40 degrees. The coldest months are July and August, when the average maximum temperature is around 18 degrees.

Similar to Perth, humidity at Kwinana is generally low and generally reaches a peak in the early mornings and then drops during the day. Winters are more humid than summers.

6.1.2 Rainfall
Rainfall in the region is seasonal, with the majority of rainfall falling during the winter months (June to August). The long term average annual rainfall for the area is 760 mm (measured at the Medina Research Centre). Rain-free months are not uncommon and have been recorded from December through to February. Mean daily evaporation ranges from 8.5 mm/day in January to 1.8 mm/day in June and July. The mean annual evaporation is 4.8 mm/day (Bureau of Meteorology, 2011).

6.1.3 Wind
Two processes cause winds in the Kwinana region:
- Large scale synoptic winds (due to the movement of high and low pressure systems across the State); and
- Local winds (induced by topographical features and by land and sea breezes).

The summer and spring weather patterns are dominated by fresh south westerly winds and sea breezes.

6.2 Geology, Soils and Topography
The geology and hydrogeology in the area around Alcoa’s Kwinana residue area is well understood from regional mapping and the strata logs recorded at approximately 600 bore sites that have been installed progressively since the mid 1970s.

The Alcoa Kwinana facilities are underlain by an unconfined (and locally semi-confined) aquifer system within the Late Tertiary to Quaternary superficial formation, comprising mainly limestone, sandstone and sand with minor silt and clay. Total saturated thickness ranges from 19 to 28 metres. The geology at the water table is illustrated in Figure 6-1, and a hydrogeological cross section from the refinery to the eastern side of the operating RSAs along the transect line shown in Figure 6-1 is shown in Figure 6-2.

The basement beneath the unconfined aquifers at the refinery and the operating RSAs is the Kardinya Shale member of the Osborne Formation, whereas beneath the closed RSA A, B and C, it is the Pinjar member of the Leederville Formation which is comprised mainly of micaceous siltstone and fine silty sandstone. Both the Pinjar member of the Leederville Formation and the Kardinya Shale have very low vertical hydraulic conductivity, especially the Kardinya Shale.

The superficial formation is comprised predominantly of Tamala Limestone composed of limestone and sand, and has very high permeability due to solution...
voids in the limestone. The permeability of this unit increases towards the coast. The Ascot Formation, located in the lower part of the superficial formation has similar lithology to the Tamala Limestone except that it is more shelly and more clayey and therefore is considered to be generally less permeable.

The Safety Bay Sand beneath the western side of the refinery and the Bassendean Sand on the east side of Area F are medium grained sands of moderately high permeability, but much lower permeability than the Tamala Limestone. The Becher Sand underlying the Safety Bay Sand and the Gnangara Sand underlying the Bassendean Sand are clayey sand aquitards that can provide separation of different groundwater quality above and below.

The topography reflects a series of variously calcified north-south trending ancient sand dunes.

6.3 Hydrology

6.3.1 Groundwater

The depth to water in the natural ground ranges from about 2 to 45 metres and largely depends on the elevation of the ground surface. Variations in the slope of the water table from east to west reflect changes in aquifer transmissivity. To the west of Area F the water table is nearly flat and within 1 metre of sea level, because of the extremely high transmissivity of the Tamala Limestone. Beneath Area F the water table has a relatively steep slope owing to the sandy strata in this area having lower transmissivity. The water table elevation is approximately 11 metres above sea level at the north-eastern corner of Area F. The water table level varies seasonally by 0.3 metres to 1 metre due to variations in rainfall recharge and the mean sea level.

The direction of groundwater flow is generally westwards. Near the coast the Safety Bay Sand, with intrinsic lower hydraulic conductivity than the Tamala Limestone causes groundwater flow to divert to the north west of Areas A, B and C and the refinery. Although the Tamala Limestone contains small solution voids that impart the very high hydraulic conductivity, on a larger scale there do not appear to be preferred pathways. All of the residue facilities are constructed entirely above the water table.

The groundwater in the superficial aquifer of the area is recharged mainly by direct infiltration of rain water. The remainder of the rainfall evaporates or is drawn out by vegetation roots before it reaches the water table. A reduction in rainfall due to climate change may result in a reduced proportion of rainfall recharging to the groundwater in the future.

Saline water intrudes into the unconfined aquifer from the sea. The main wedge of saline water on the base of the aquifer

Figure 6-1: The geology at the water table.
Alcoa's Response
Alcoa will continue its six monthly water sampling program at Wellard and will develop and implement ongoing land management programs for wetland areas located on its land. Alcoa will include the Wellard wetlands in the triennial fauna assessment on a periodic basis.

Alcoa has previously sponsored a range of wetland research programs. At this time Alcoa does not see the need for further research.

6.4 Flora and Fauna

6.4.1 Flora
A significant proportion of the vegetation surrounding the residue area was cleared many years before construction of the residue area commenced. There are pockets of native vegetation remaining in the area, many of which are now protected. These include the Bush Forever sites adjacent to the residue area and The Spectacles wetlands to the south east.

Floristic surveys (Bennett Environmental Consulting Pty Ltd, 2002) identified six main vegetation communities in the region:
1) Low Open Forest of Eucalyptus marginata (commonly known as Jarrah) and Banksia attenuata (Candlestick Banksia) over an Open Heath dominated by Xanthorrhoea preissii (Grass tree) or Acacia pulchella (Prickly Moses) in greyish brown sand.
2) Woodland of Eucalyptus gomphocephala (Tuart), Eucalyptus marginata (Jarrah), Banksia attenuata (Candlestick Banksia) and Allocasuarina fraseriana (Sheoak) over an Open Heath dominated by Xanthorrhoea preissii (Grass tree) or Acacia pulchella (Prickly Moses) in greyish brown sand.
3) Woodland of Eucalyptus gomphocephala (Tuart) and Eucalyptus marginata (Jarrah) with occasional to dense Banksia attenuata (Candlestick Banksia) over a Shrubland of mixed species dominated by Xanthorrhoea...
preissii (Grass Tree) and Macrozamia riedlei (Zamia Palm) in brownish yellow sand.

4) Low Open Forest of Agonis flexuosa (Peppermint Tree) over a Low Shrubland of Grevillea vestita and a Herbland dominated by weeds in grey, slightly moist sand.

5) Closed Tall Scrub or Low Shrubland of Acacia rostellifera (Summer Scented Wattle) over a Very Open Herbland in brownish yellow sand with limestone outcropping.

6) Closed Tall Scrub to Shrubland of Melaleuca huegelli (Chenille Honey-myrtle) over a herbland of weeds in brownish yellow sand with limestone outcropping.

Complex 6 is listed by the DEC as a Threatened Ecological Community (Floristic Community Type 26a). This vegetation complex occurs on Alcoa’s property in an area between the access road to the residue area and Anketell Road. Alcoa has protected the area under a management plan.

No rare or priority plant species have been detected (Bennett, 2002).

6.4.2 Fauna

Prior to construction of the residue area, the presence of native fauna in the residue area was limited. Species diversity and populations were consistent with those typically found on agricultural grazing lands. Alcoa introduced a land management program at Kwinana in 1992 which has focused on revegetating areas surrounding the refinery and residue areas. These rehabilitated areas provide habitat for local fauna.

In 1999, Alcoa commissioned a flora and fauna survey on Alcoa land near the Kwinana refinery and residue areas. The objectives of the survey were to document native vegetation communities and fauna habitats, and determine whether any officially gazetted rare or uncommon plant or animal species were known or likely to be present. A second objective was to document any degradation including that due to feral fauna species or weed invasion. From the information gathered, recommendations for the management and rehabilitation of areas were developed.

Subsequent triennial fauna surveys were undertaken in 2002, 2005, 2008 and 2011 to gather information to develop recommendations for ongoing management of vegetation and fauna. In 2008, a survey of native vegetation along Anketell Road was undertaken and a flora and fauna survey was undertaken in the area proposed for the future Area O. In 2011, the fauna and flora survey focused on the Threatened Ecological Community, the beachfront and the rehabilitated area to the east of Abercrombie Road. Recent fauna surveys have observed Carnaby’s Black Cockatoo perching on tree branches in remnant vegetation to the east of Postans Road. Potential feeding grounds for this species exist within the site. This species is protected under the Environment Protection and Biodiversity Conservation Act (1999) and the Wildlife Conservation Act (1950).

6.4.3 Flora and Fauna Guiding Principles and Alcoa’s Commitments

In response to the information provided, the Kwinana LTRMS SRG developed one guiding principle relating to the flora and fauna.

Guiding Principle: Flora and Fauna

Alcoa shall continue the triennial assessment programs for Flora, Fauna and Land Management.

Alcoa’s Response

Alcoa will continue to develop and implement land management programs on an annual basis.

6.5 Aboriginal Heritage Sites

6.5.1 Aboriginal Heritage

Alcoa has commissioned a number of Aboriginal Heritage studies of the areas in close proximity to the residue area in recent years. Typically, these studies are conducted through archival searches of the Department of Indigenous Affairs (DIA) site registers; consultation with Aboriginal heritage consultants who are recognised as being the appropriate people to speak for Aboriginal interests in the area; and field surveys of areas proposed for development. These surveys focus on the identification of any archaeological or ethnographic sites in the study areas and are conducted in accordance with the Guidelines for Aboriginal Heritage Assessment released by the Minister for Aboriginal Affairs in October 1993.

The most recent of these studies was completed in February 2009 and focussed on the areas proposed for the development of Areas O and P. During this study, no new ethnographic or archaeological sites were identified in the area. The study did identify that within a radius of approximately five kilometres of the Survey Areas there are 12 previously recorded Aboriginal sites that will not be affected by the proposed residue storage areas.

6.5.2 European Heritage Sites

There are no heritage sites registered on the State Register of Heritage Places located within one kilometre of the residue area. However, 18 European Heritage sites within one kilometre of the residue area are listed on the Heritage Council of Western Australia’s places database. The Places Database includes heritage places listed on local government heritage inventories, Commonwealth heritage lists and the List of Classified Places managed by the National Trust of Australia (WA), or included in surveys and studies. These sites include historic buildings or ruins, urban parkland, natural features such as dunes or swamps and other historic places (Heritage Council of WA, 2012). Of these 18 sites listed on the Places Database, 3 have been demolished.
6.5.3 Heritage Guiding Principles and Alcoa’s Commitments

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

Guiding Principle: Heritage
Alcoa shall continue to work towards protecting Aboriginal and European heritage.

Alcoa’s Response
Alcoa will continue to survey for Aboriginal and European heritage sites within the footprint of new residue areas, and where applicable, will develop management plans for those sites.

6.6 Existing Land Use and Tenure
Alcoa owns a number of landholdings within the Kwinana-Rockingham area, ranging from the refinery site located within the Kwinana Industrial Area, to rural land from which clay is extracted for use in the construction of residue areas.

The existing residue area footprint is 543 hectares. The residue area is under freehold ownership by Alcoa and is zoned Rural B for bauxite residue drying and storage. The majority of property surrounding Alcoa’s residue area is privately owned.

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 City of Kwinana and the City of Cockburn.

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 structure plan identifies potential development areas, road networks, major community facilities, conservation wetlands, Bush Forever sites and neighbourhood structure based on Liveable Neighbourhoods principles, and includes proposals for the implementation of the plan such as zoning mechanisms, staging, and financial and management arrangements (Western Australian Planning Commission, 2007).

6.7.1 Metropolitan Region Scheme

The Metropolitan Region Scheme (MRS) is a large town planning scheme for land use in the Perth metropolitan area. The MRS covers the whole of the Kwinana residue area and surrounding land. The MRS identifies a range of zones within which certain land uses will be permitted and acts as an overriding instrument that can be used to apply regional land use planning objectives. The MRS defines future use of land, defining it into broad zones and reservations. It requires local government town planning schemes to provide detailed plans for their part of the region. These schemes must be consistent with the MRS.

Alcoa Kwinana residue area is classified Rural under the MRS (Department of Planning, 2011).

The structure plan identifies potential development areas, road networks, major community facilities, conservation wetlands, Bush Forever sites and neighbourhood structure based on Liveable Neighbourhoods principles, and includes proposals for the implementation of the plan such as zoning mechanisms, staging, and financial and management arrangements (Western Australian Planning Commission, 2007).

6.7.3 Hope Valley Wattleup Master Plan

The Western Australian Land Authority (LandCorp) prepared the Hope Valley – Wattleup Master Plan (2008) in accordance with the Hope Valley Wattleup Redevelopment Act 2000. In accordance with the Environmental Protection Act 1986, an Environmental Review was also prepared which describes the Hope Valley Wattleup Master Plan and its likely effects on the environment.

The Master Plan aims to:
1. protect the Kwinana Industrial Area by resolving surrounding land use conflicts;
2. protect significant heritage in the Redevelopment Area;
3. conserve areas of local and regional environmental significance;
4. minimise sources of pollution;
5. distribute the cost of common infrastructure;
6. ensure the development and use of land within the Redevelopment Area comply with accepted standards and practices;
7. ensure that future development and land use within the Redevelopment Area occur in a proper and orderly way;
8. promote sustainable development; and
9. facilitate development generally in accordance with the Master Plan Report and Planning Strategy.

The Master Plan divides the Redevelopment Area into precincts to identify areas for particular uses and identifies land reserved for public purposes. Most importantly, the Master Plan provides a broad planning framework at the regional level. It seeks to coordinate and plan the development expectations of the region while balancing environmental constraints, conservation, infrastructure provision and lifestyle, and community and neighbourhood objectives.
Plan controls the types of uses and development allowed in the various precincts. The Proposed Master Plan sets out the requirements for planning approval, nonconforming uses and enforcement of the Proposed Master Plan provisions.

The majority of land within the Hope Valley Wattleup Master Plan is earmarked for general industrial use. Within the immediate vicinity of the residue area, the Master Plan proposes general industry to the west, low intensity business park to the north and an area north of Rowley Road where the final land use is subject to the Environmental Protection Policy (EPP) Buffer Review process.

6.7.4 Kwinana Industrial Buffer
The Kwinana Industrial (including Air Quality) Buffer is an area established by the WA Planning Commission around the entire Kwinana Industrial Area that aims to provide a separation distance between industries (which may have a variety of potential impacts including emissions, dust, noise, light and odour) and other land uses, such as residential development.

By maintaining a separation distance between industry and residential development the buffer area also seeks to avoid restrictions being placed on the activities and operations of industry within the industrial buffer.

The Review of Kwinana Air Quality Buffer was released for public comment in August 2002. The review recommended modification to the existing buffer in six areas and identified three additional areas which were subject to further investigation. These areas were reviewed again recently, taking into account changing circumstances and available information. Correspondence from the Western Australian Planning Commission (WAPC) to all land holders near the Kwinana residue area sent in October 2011 indicated that the review of the buffer to the north, northeast and east of Alcoa’s Kwinana residue area and around the Water Corporation’s Wastewater Treatment Plant was finalised in September 2010, after the Western Australian Planning Commission considered technical advice from the Department of Health and Department of Environment and Conservation.

The expanded buffer includes a 1 kilometre area around the residue area where future residential expansion is restricted, with an additional 0.5 kilometre beyond that restricts residential expansion and development of some sensitive land uses (e.g. kindergartens, hospitals and aged persons housing) (WAPC, 2011). The purpose of the additional area is to recognise uncertainties inherent in the level and frequency of impacts from Alcoa's residue area and the Kwinana Industrial Area more broadly. The review has expanded the buffer in these areas. This portion of the buffer is due to be reviewed in five years time to ensure that its extent and location are still appropriate for the current conditions in the area (WAPC, 2011).

As part of the review process, the steering committee for the Review of the Kwinana Air Quality Buffer requested that Alcoa submit the detailed dust study that was undertaken by GHD on behalf of Alcoa in 2008 and 2009 for consideration. This study showed that dust emanating from Alcoa’s residue area could, under certain weather conditions, be detected up to 2 km away. Alcoa submitted this study to the Kwinana Air Quality Buffer Steering Committee in early 2010.

6.7.5 Local Planning Strategies

City of Kwinana Town Planning Scheme
The City of Kwinana Town Planning Scheme establishes a Rural B zoning over the residue area. As part of the current mid-term development plans, Alcoa has identified the need to relocate the existing water storage facilities from the existing footprint to a nearby location (see Section 8.6.3 for more detail). To facilitate the relocation of these facilities, any new location will need to be zoned “Rural B” so a rezoning process is likely to be required.

City of Cockburn Town Planning Scheme
The boundary between the City of Cockburn and the City of Kwinana is approximately 1 km north of the residue area. Land north of the residue area is zoned rural and development.

Land located just north of the City of Kwinana-Cockburn boundary along Wattleup Road is within the City of Cockburn’s Development Zone. This land is currently proposed for subdivision for residential development. These lots fall within the 0.5 kilometre residential development and sensitive use exclusion area of the revised Kwinana Industrial (including Air Quality) buffer.

6.7.6 Land Use Planning Guiding Principles
Guiding Principles developed by the SRG for land use planning can be found in Section 8.4.4.
existing environmental issues and management strategies

7.1 Environmental Management Systems

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 1995. Subsequently, the EMS was extended to the remainder of the Kwinana Refinery, which gained ISO 14001 certification in December 1997. 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;
- 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 Kwinana LTRMS SRG.

7.2 Dust

7.2.1 Background

One of the key community concerns discussed by the Kwinana LTRMS SRG related to dust from the residue area and management strategies to control dust.

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. For more information on residue emissions and health, see Section 7.5.

In addition to the drying beds, the surrounding infrastructure such as roads, embankments, and drains can also be a source of airborne dust and are managed accordingly.

Dust impacts from the residue areas are predominately 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 factors including atmospheric conditions and the size, shape and mass of the particles. It is also known that other neighbourhood dust sources also have a significant wind erosion dust component (GHD, 2009).

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 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.

Alcoa’s Kwinana Refinery received a total of 54 complaints related to dust from the residue areas between 2005 and 2011. The annual number of dust complaints has decreased since 2008, with a significant reduction in the number of dust complaints received each year. Despite the potential for the residue area to generate dust, the 2009 GHD Dust Study demonstrated that there are many significant neighbourhood dust sources near the residue areas and monitoring has shown the residue area has similar significance to other neighbourhood dust sources, such as quarries and market gardens (GHD, 2009). Although no health complaints have been registered with the refinery since 2008, complaints and feedback indicate that the nuisance associated with dust deposition on private property still concerns some community members.
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 Kwinana, 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 seven day and seasonal weather forecasts. These are reviewed weekly and allow Alcoa to maintain preparedness for conditions conducive for dust generation by, for example, operating sprinklers well ahead of forecast winds. In addition, the following specific mid-term dust control methods are employed by Alcoa to minimise dust generation:

- regularly turning over the mud in the drying area thereby leaving wet mud on the surface;
- spraying exposed banks and roads with dust suppressants;
- restricting vehicle access to exposed areas; and
- investigations into exceedances of internal targets to prevent recurrences.

Day-to-Day Controls

The specialist consulting company also supplies local one day and three day weather forecast on a daily basis, which include a Dust Risk Rating that takes into account rain, wind speed and wind direction. The main day to day control mechanism to manage dust emissions from the drying beds is the use of the sprinkler system.

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.
7.2.3 Dust Management Changes since 2005

Carbonation
Increased residue caustic concentrations increase the formation of carbonate on the residue surface.

Alcoa has implemented a carbonation plant at Kwinana using waste CO₂ from the CSBP ammonia plant. Through reducing the pH of the residue, the carbonation process has the potential to reduce dust caused by carbonated residue forming on the surface of the drying beds.

See Section 4.6.3 for more detailed information about carbonation.

Sprinkler System Upgrade
The original sprinkler designs used at the Kwinana 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 Kwinana 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 Kwinana in 2006. 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 Kwinana 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 cheaper 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, while smaller size fractions can be inhaled. The terminology for dust size fractions monitored historically at Kwinana is as follows:

- TSP (Total Suspended Particulate Matter) – particles with an aerodynamic diameter <50 μm; and
- PM₁₀ (particulate matter <10 μm) – particles with an aerodynamic diameter <10 μm.

Alcoa’s Kwinana Refinery DEC licence requires Alcoa to operate and maintain a dust monitoring program that measures TSP and PM₁₀ dust levels. Alcoa operates five licensed TSP monitors, two licensed real time PM₁₀ monitors and several additional real time non-licensed monitors to provide background information and information on total dust levels around the residue area. The two real time PM₁₀ dust monitors and two real time non-licensed dust monitors are linked to process control computers, and provide immediate feedback to operators on dust levels so they can enact targeted control measures quickly.

Figure 7-2 shows the current residue licensed dust monitoring network, and Figure 7-3 illustrates one of the dust monitoring stations.

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 do not differentiate the source (GHD, 2009).

Ambient dust monitoring at the Kwinana residue area is carried out in accordance with the DEC licence conditions. Currently dust target levels are set at 90 μg/m³ (24 hour average, non-background corrected) as determined by monitoring at licensed high volume samplers. Ambient Hi-Vol dust monitor levels which exceed 90 μg/m³ are investigated to determine the root cause(s), recorded and reported to the DEC, where required by the DEC licence.

The licensed real time PM₁₀ monitors and the real time non-licensed monitors have internal targets which alarm to the control room and area supervisors. The purpose of the internal standard is to ensure that a higher level of performance than the minimum acceptable levels is achieved and to provide early warning to Alcoa of potential dust issues.

Dust Performance
For each dust target exceedance at a licensed monitor, Alcoa completes an investigation into the meteorological conditions, potential sources and dust control measures during the sample period. When required by the licence conditions, 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 2011 there were 67 dust target exceedances at licensed monitors around the residue area. Following investigation eight of these were determined to be potentially contributed to by Alcoa operations. Residue dust was suspected to have contributed to five of these target exceedances with earthmoving and construction activities suspected to have contributed to the remaining three.

The completion of the upgrade of the dust sprinkler system in 2009 appears to have led to an improvement in dust performance. Ongoing improvements in dust management are discussed in the annual environmental reports to the DEC and at EIP meetings.

### 7.2.4 Residue Dust Studies

**WAO Residue Dust Study**

Following on a PM$_{10}$ and PM$_{2.5}$ study performed at Wagerup in 2002-03, Alcoa conducted a detailed study into residue dust to quantify the chemical makeup of the dust emissions and the particle size distribution of residue dust. The study aimed to assess the quantity of PM$_{10}$ and PM$_{2.5}$ in dust emissions and at receptors, compare these concentrations to National Environment Protection Measures (NEPM) standards and assess the physical and chemical properties of residue dust. The information was then used in a quantitative health risk assessment of residue emissions and to further understand the impacts on amenity.

The results from the residue dust study and associated health risk assessment are discussed in Section 7.5.

**Kwinana Residue Dust Studies**

Dust emissions from Kwinana’s residue area have been the subject of several comprehensive studies. The most recent studies were completed in 2004 and 2008-09.

In 2004, Sinclair Knight Merz (SKM) studied and modelled Kwinana residue area dust emissions. This study had four major tasks. The first task consisted of ambient dust monitoring at two locations in the community for three summer months. This was to determine existing dust levels and to validate and calibrate a dust model. The second task was to use portable dust monitors in the area surrounding the residue area to conduct emissions testing. This was undertaken to estimate dust emissions from the residue area as a function of wind speed. Third, an evaluation of wind speed across the residue area was undertaken. The wind speed-up (as a function of prevailing wind direction) was estimated using a Wind Assessment Siting Program (WASP), and this data was then used to factor in wind direction. The final task was the development of a dust model in order to estimate dust levels for the area around the residue area. The model incorporated data from the previous tasks and predicted the spatial extent of dust levels. This assisted in determining areas where dust levels may exceed those of applicable dust standards.

Following feedback from the DEC on the SKM study, upgrades to Alcoa’s residue area sprinkler network (see Section 7.1.3 for details) and the implementation of residue carbonation (see Section 4.6.3 for details), in 2008, GHD was commissioned by Alcoa to improve, extend and update the SKM (2004) modelling study to better understand the dust emission impacts in the area. This work was completed over a two year period and was completed at the end of 2009.

GHD were tasked with expanding, extending and improving previous dust models to increase confidence in the dust emission predictions. The objective of the study was to assess the extent and magnitude of dust emissions that may relate to health or amenity...
Alcoa operates five licensed TSP monitors, two licensed real time PM$_{10}$ monitors and several additional real time non-licensed monitors to provide background information and information on total dust levels around the residue area.

Concerns from existing or potential neighbours. In doing this, the study led to improvements in the predictions relating to the extent of dust impacts and provided a better understanding of the dust generating processes at the residue area. The outcomes of the study are intended to inform land use planning decisions in adjacent areas, modification of dust management techniques and adaption to potential climate changes in future years.

Alcoa was requested to submit this study to the Kwinana Air Quality Buffer Steering Committee for consideration in its review of the Kwinana Industrial (including Air Quality) Buffer. Alcoa submitted this study to the committee in early 2010 (see Section 6.8.4 for more detail).

7.2.5 Dust Guiding Principles and Alcoa’s Commitments

In response to the information provided, the Kwinana LTRMS SRG developed five guiding principles relating to dust. These are presented below, together with Alcoa’s response.

Guiding Principle: Control and Improvement

Alcoa to research and implement improved methods of dust control with the objective of eliminating offsite dust impacts.

Alcoa’s Response

Alcoa is committed to its dust management program and continues to seek improvement of dust control measures. In addition, Alcoa will continue to evaluate new dust control measures as they become available.

Guiding Principle: Education

Alcoa to develop initiatives and disseminate information that assists the community to understand how dust is measured, relevant dust standards and levels of compliance.

Alcoa’s Response

Alcoa currently seeks relevant opportunities to disseminate information to stakeholders to assist them to understand how dust is measured, relevant dust standards and levels of compliance. These initiatives include Alcoa’s Environmental Improvement Plan (EIP) process and the Kwinana Community Industry Forum. This will be continued in the future.
**Guiding Principle: Monitoring**

Alcoa shall develop a clear long term dust monitoring plan in consultation with the community and the DEC to evaluate:

1. Dust impacts
2. Radiation levels from dust
3. Health impacts from dust and
4. The success of dust management strategies.

**Alcoa’s Response**

Alcoa’s dust monitoring programme is reviewed and updated annually. Alcoa will continue to monitor dust in accordance with DEC licence conditions and in consultation with the EIP working group, to whom it regularly reports on the effectiveness of dust management strategies.

Alcoa recently undertook a study on radiation exposure for its WA Operations, including residue. This study found exposures were below relevant Australian standards. Should Alcoa’s processes change significantly in the future, Alcoa will review the study to reassess exposure levels.

In addition, Alcoa has completed a comprehensive Health Risk Assessment (HRA) to assess ground level concentrations of compounds against relevant national and international health guidelines. The full report is available online at: http://www.alcoa.com/australia/en/pdf/HRA_Pinjarra_Dust_21_August_08.pdf

**Guiding Principle: Monitor Locations**

Alcoa to change the location and the number of dust monitors to ensure that dust monitoring occurs near existing and planned residential development. This is to help focus on the areas for improvement as part of dust management in the RSA.

**Alcoa’s Response**

Alcoa believes the current number and location of dust monitors is adequate.

The location of licensed dust monitors is regularly reviewed by Alcoa and the DEC. Where opportunities for improvement are identified, monitors are relocated; e.g. the Mortimer Farm/Residue West monitor was relocated recently.

In addition, Alcoa operates a number of non-licensed dust monitors to further assist with dust management strategies.

Dust monitor locations are determined based on the following:

- Approval by the DEC;
- Potential for impacts from other sources and land uses (must be minimal);
- Approval by the owners of the land where the monitors are situated;
- Accessibility by Alcoa personnel (Alcoa must have full access rights);
- Availability of power;
- Clearance from vegetation;
- Suitability of topography; and
- Compliance with relevant Australian Standards.

**Guiding Principle: Access to Data**

Alcoa to establish a live website that displays live dust monitoring information for the RSA.

**Alcoa’s Response**

Alcoa believes the current level of dust monitoring reporting is adequate.

Alcoa investigates and reports dust complaints and dust target exceedances to the DEC, in accordance with the DEC licence. When a complaint is received, the community member is offered the opportunity to discuss the findings of the investigation.

In addition, Alcoa currently reports dust monitoring data, which includes the total dust levels from both Alcoa and non-Alcoa sources, to the EIP working group on a quarterly basis.

**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. VOCs are a class of chemical compounds that are readily released from water or air emissions at normal temperatures.

**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 Alumina 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. Because of the similarities in relevant processes between the Wagerup and Kwinana Refineries these findings can be applied to the Kwinana 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 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.

Based on the outcomes of the Wagerup study, the higher sources of odour for Kwinana are likely to include the Cooling Pond and super-thickener. Lower sources of odour at the Kwinana residue area are likely to include the wet drying areas (including Area H), dry residue areas, low concentration cool liquid sources (for example lake water pond and surge ponds), and the new Oxalate Bio-removal process. Monitoring of the bio-removal process has since confirmed that it is not a significant source of odour. Overall, odour emissions from the Kwinana residue were not regarded as significant by the SRG, and Alcoa’s community complaint data supports this.

Alcoa has significantly reduced its use of Cooling Pond water in sprinklers for dust suppression in recent years, and this has resulted in a decrease in odour and VOC emissions from residue areas.

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

Any expansion of drying areas has a minimal impact on odour and VOC emissions from residue given the amount of fresh mud being deposited remains relatively stable. Odour and VOC emissions are more impacted by the temperature and VOC concentrations of liquor streams. Liquor reporting to residue comes from a number of different sources in the refinery, each with differing temperatures and concentrations of VOCs. The liquor content of the residue material deposited at the residue areas is minimised so the RSAs are regarded as a low odour and VOC emission source.

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

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

**Guiding Principle**

Alcoa to characterise the odour from the RSA and assess the impact of odour on the community.

**Alcoa’s Response**

In 2004, odour and volatile organic compound (VOC) emissions from various residue sources at Alcoa’s Wagerup Refinery were measured directly for the first time. This study was submitted to the DEC as part of the environmental assessment for the approved Wagerup Unit Three expansion. 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.

The study concluded that odour emissions from residue areas are not regarded as significant.

These findings are applicable to the Kwinana residue area and Alcoa believes that further research would not alter these conclusions.

### 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 residue area 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). All 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 in 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.

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.

### 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 residential areas in Perth.

### 7.4.6 Radiation Guiding Principles and Alcoa’s Commitments

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

**Guiding Principle**

**Alcoa’s Response**

The International Atomic Energy Agency recently developed guidelines on the management of materials that contain naturally occurring radioactive material. Australia has adopted these guidelines, which require materials with radiation levels above 1 Bq/g to be subject to specific monitoring and reporting. The State Government is yet to implement these guidelines.

Alcoa conducted an assessment of Naturally Occurring Radioactive Materials across all of its WA locations. Alcoa is currently finalising the report on this assessment which will be submitted to the Radiation Council of WA.

The assessments showed that all results were below Australian public exposure standards.

As the study found Alcoa’s workforce exposure is less than Australian public exposure standards, Alcoa will request an exemption to these guidelines so that ongoing monitoring is not required. The assessments concluded that exposure to the community is lower than the exposure to the workforce.

### 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 residue areas, 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. In particular, a monitoring site at Kwinana was used in order to observe the effect on dust of being near the sea, other industries and urban activities in contrast to a rural setting near Pinjarra.

Monitoring ran over 18 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 National Association of Testing Authorities (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 residue area 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 Tapered Element Oscillating Microbalances (TEOMs) worked well & indicated that the residue area can contribute the majority of total suspended particulates (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);

<table>
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<th>Gamma</th>
<th>Radon Progeny</th>
<th>Total Dose (Ann)</th>
<th>Standard</th>
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<td>&lt;0.24</td>
<td>1</td>
</tr>
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<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>
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<td>RSA Central</td>
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<td>&lt;0.10</td>
<td>&lt;0.42</td>
<td></td>
</tr>
</tbody>
</table>

Table 7-1: 2008-09 NORM monitoring results for residue personnel.
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 Australia, 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 expanded residue area 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 residue dust;
• the potential for emissions from the baseline or expanded residue area to cause chronic health effects represents no cause for concern; and
• the potential for emissions from the baseline or expanded residue area to contribute to the incidence of cancer based on inhalation exposure is low; below the United States Environmental Protection Agency (USEPA) de minimis threshold of one in a million (i.e. 1 x 10$^{-6}$).

These results reinforce that Alcoa’s operations are safe for both employees and neighbouring communities. They indicate that the composition of the dust has extremely low levels of trace metals, and the estimated cancer risk level is well below the global recommendation set by the USEPA of one in a million.

7.5.4 Guiding Principles and Alcoa’s Commitments
In response to the information provided, the Kwinana LTRMS SRG determined that a guiding principle around health impacts of residue dust was not required.

7.6 Waste
7.6.1 Background
Waste generated at the Kwinana 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 the breakdown of organic material (plant and animal matter) from where the bauxite is mined. Within the refinery process this organic matter forms 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 Kwinana 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 reduction of waste to landfill through new and improved recycling programs with advances having been made in the area of waste recycling and minimisation.

Alcoa’s waste management program has been developed to the point where it includes the recycling of waste oil, scrap metal, gloves, fluorescent lights, automobile batteries, liquid waste, electronic waste, cardboard, cooking oil and printer/toner cartridges. Alcoa also operates a worm farm and composting facility at its Pinjarra Refinery that collects and processes all organic based waste produced at each of Alcoa’s locations in Western Australia. 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 RSAs. 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 using several techniques:
- Oxidised using an Oxalate Kiln;
- Reacted with lime (to form calcium oxalate) and stored within residue mud;
- Sold to a third party for use in an industrial process; and
- Stored in oxalate ponds for future destruction.

Alcoa has constructed and commissioned an Oxalate Bio-removal plant at Kwinana to destroy excess and stored oxalate. The plant was commissioned in 2009 and is the first plant of its kind in the world. Bio-removal is a bacterial process that breaks down the sodium oxalate and produces significantly less carbon dioxide than burning.

The Kwinana Refinery’s operating licence has been modified to reflect this new management strategy for oxalate.

### 7.6.3 Waste Guiding Principles and Alcoa’s Commitments

**Background**

In response to the information provided, the Kwinana LTRMS SRG determined that a guiding principle around waste was not required.

### 7.7 Water Use

#### 7.7.1 Background

The Kwinana 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; ground water recovery and production bores on site; potable water and water brought in with bauxite (% moisture). The only losses of water from the refining system are as steam and moisture from the refining process, evaporation from water storage areas and residue surfaces, and water bound within the residue mud and sand. Aside from evaporation, there is no discharge of process water to the environment. The largest use of water at the residue facilities is for operating sprinklers to control dust. The Kwinana Refinery used 3.49 kilolitres of water per tonne of alumina product (annualised figure) in 2011.

The RSAs have base drainage systems that collect and recycle 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

**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 installed and commissioned the ROWS pond in 2006 to increase water storage capacity and allow sprinklers to be run on production bore water, good quality recovery bore water and good quality condensate. This reduces carbonate formation and risks of overspray.

Sprinkler spacing has been revised to improve efficiency, and carbonation of residue mud has been introduced which reduces dust generation therefore reducing dust suppression requirements.

Alcoa has developed a Water Efficiency Management Plan in conjunction with the Water Corporation to improve potable water management. This plan focuses on using water of a quality that is ‘fit for purpose’ and substituting higher quality water with lower quality water where possible.

The objectives of this plan are to:
- Assess current water use on site from all sources;
- Identify inefficiencies and potential water conservation measures;
- Prepare an action plan to implement water conservation actions; and
- Provide a platform for annual reporting on implementation of water conservation actions.

Alcoa is undertaking ongoing research into alternative water sources and water conservation initiatives.

### Impact of Expanded Residue Area

The amount of water required for dust suppression is related to the open drying area. Because the Kwinana Refinery is currently operating with a residue drying area deficit, bringing online new drying areas to restore the optimum drying area in the next 5-10 years will increase sprinkler water use.

However, with a stable production rate, the amount of drying area at the residue area will remain relatively constant (new areas will increase the open area but will then be consumed over time).

### Guiding Principles and Alcoa’s Commitments

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

#### Guiding Principle

The RSA to utilise treated water from the Kwinana Wastewater Treatment Plant (on McLaughlan Rd) for all non-potable needs.

#### Alcoa’s Response

Alcoa will continue to conserve water through reuse and reduction initiatives, and identification of alternative sources. Alcoa is currently progressing a project...
with the Water Corporation to reuse water from the Kwinana Wastewater Treatment Plant. This is subject to regulatory support and approval. The volume of treated wastewater obtained under this project is limited and will not be sufficient to replace all non-potable water needs, and the water will not be suitable for all non-potable water uses.

7.8 Surface Water

7.8.1 Background
The Kwinana Refinery operates a closed water circuit, meaning that the refinery does not discharge any process water from the site. 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.

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. All rainfall runoff from the residue areas and process water ponds is transferred to the Cooling Pond during winter and then used as make-up water for the refinery during summer.

Surface water runoff and underdrainage is collected in a Runoff Collection Pond (ROCP) and pumped to the Cooling Pond.

Under normal rainfall conditions water collected on the surface of the RSAs 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 on 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.

In 2006, Alcoa commissioned the new 2,000 ML ROWS Pond which increased the capacity to store winter runoff for a 1 in 100 year annual rainfall event. The ROWS Pond has three main functions. The primary function of the ROWS pond is to collect surface runoff water and water pumped under licence from the production bores. This water has very low alkalinity and provides water to the residue sprinkler system. 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 increase the capacity to store winter runoff for a 1 in 100 year annual rainfall event by providing extra water storage capacity if the Cooling Pond reaches its maximum operating level. During a normal rainfall year, all of the water runoff from the residue areas should be accommodated in the Cooling Pond with no transfer to the ROWS Pond. If the Cooling Pond reaches its maximum operating capacity, the additional water will be transferred to the ROWS Pond.

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. These strict design standards are implemented to ensure the stability of the residue areas and to minimise the potential environmental risk.

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

7.8.3 Guiding Principles and Alcoa’s Commitments
In response to the information provided, the Kwinana LTRMS SRG determined that a guiding principle relating to surface water was not required.

7.9 Groundwater

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 Kwinana.

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 in 1987 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.
Alcoa monitors the effectiveness of the recovery bore network using an extensive network of more than 500 groundwater monitoring sites, and the results are reported to the DEC and DoW annually in accordance with licence conditions.

As part of the monitoring program, Alcoa continually assesses the need for additional recovery bores to improve the capability of the existing recovery network and where required additional monitor bores to delineate and track the existing plumes. Figure 7-5 shows one of Alcoa’s monitor bores.

Currently the groundwater program is reviewed annually by an independent hydrogeologist, who recommends appropriate groundwater abstraction rates to manage the plumes.

The Groundwater Monitoring and Management Plan is dynamic and is continuously developed as opportunities for improvement are identified. A number of improvements to the groundwater management process have previously been identified and are already being implemented.
Based on currently available information the source is suspected to be an underdrain sump (or associated pipe work) rather than defects in the base liner or penetration of the clay seal. The five underdrain collection sumps at Area H are located outside the base liner, whereas the underdrain system and sumps in each of the subsequent residue areas are contained above the base clay/synthetic liners. Alcoa is currently investigating recovery options for this contamination.

**7.9.3 Groundwater Monitoring**

The primary objective of the Groundwater Monitoring Program is to assess the effectiveness of the groundwater management activities and to determine if changes to the groundwater management plan are required. 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; and
- Assessing the effectiveness of the management plan in controlling existing plume.

Previous work has been carried out to identify and plug potential leaks in the clay seal for Area F. This effort was partially successful, however the work showed that this is not a sustainable strategy. Area F is now mostly closed and with only a small area to the north east remaining open for residue storage. Alcoa is currently progressing plans to cease the use of this area and develop a detailed closure plan for the area.

**Area H**

Area H is the second oldest operating residue area, built in 1984. A small plume was identified in 2007 to the north of Area F, near the western dyke of Area H. This plume is narrow and concentrated, and is approximately 50 metres wide and is contained within Alcoa’s property boundary.

Preliminary work has been carried out to determine a closure plan for Area ABC. Trial de-liquoring bores were installed and tested, however liquor recovery rates were less than expected. Alcoa is currently re-examining options for de-liquoring.

Groundwater in this area moves in a general north westerly direction. Currently there are thirteen recovery bores positioned to the north of Area A, so as to actively control and contain this plume.

**Area F**

Alcoa currently has seven groups of recovery bores positioned around Area F to contain the spread of the groundwater contamination. These bores are primarily positioned along the western and southern edges of the area. The highest concentrations in both the upper and lower parts of the aquifer are in the area between the west-north-west and south-west recovery systems. Significant concentrations associated with Area F do not extend more than approximately 100 metres from the Area F dyke, with the exception of the dilute plume to the northwest that extends approximately 900 metres. It is estimated that the alkali flux and plume concentrations have been steady at the Area F plumes in the last three to four years.

Previous work has been carried out to identify and plug potential leaks in the clay seal for Area F. This effort was partially successful, however the work showed that this is not a sustainable strategy. Area F is now mostly closed and with only a small area to the north east remaining open for residue storage. Alcoa is currently progressing plans to cease the use of this area and develop a detailed closure plan for the area.

**ABC Area**

In general terms the alkali concentration beneath the closed residue areas (Area ABC) is relatively stable year to year. When the plume was first identified in 1974, it already extended outside the northern boundary at Area A. The plume currently extends approximately 900 metres to the north-west of the boundary, where it is neutralised by the saline wedge from the ocean. It is important to note that neutralisation by the saline wedge is not Alcoa’s preferred remediation approach.

Groundwater in this area moves in a general north westerly direction. Currently there are thirteen recovery bores positioned to the north of Area A, so as to actively control and contain this plume.

Alcoa currently has seven groups of recovery bores positioned around Area F to contain the spread of the groundwater contamination. These bores are primarily positioned along the western and southern edges of the area. The highest concentrations in both the upper and lower parts of the aquifer are in the area between the west-north-west and south-west recovery systems. Significant concentrations associated with Area F do not extend more than approximately 100 metres from the Area F dyke, with the exception of the dilute plume to the northwest that extends approximately 900 metres. It is estimated that the alkali flux and plume concentrations have been steady at the Area F plumes in the last three to four years.

Previous work has been carried out to identify and plug potential leaks in the clay seal for Area F. This effort was partially successful, however the work showed that this is not a sustainable strategy. Area F is now mostly closed and with only a small area to the north east remaining open for residue storage. Alcoa is currently progressing plans to cease the use of this area and develop a detailed closure plan for the area.

**Area H**

Area H is the second oldest operating residue area, built in 1984. A small plume was identified in 2007 to the north of Area F, near the western dyke of Area H. This plume is narrow and concentrated, and is approximately 50 metres wide and is contained within Alcoa’s property boundary.

Groundwater in this area moves in a general north westerly direction. Currently there are thirteen recovery bores positioned to the north of Area A, so as to actively control and contain this plume.

**7.9.3 Groundwater Monitoring**

The primary objective of the Groundwater Monitoring Program is to assess the effectiveness of the groundwater management activities and to determine if changes to the groundwater management plan are required. 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; and
- Assessing the effectiveness of the management plan in controlling existing plume.

Alcoa is currently investigating recovery options for this contamination.
To achieve this Alcoa maintains an intensive groundwater monitoring network consisting of internal residue area bores, residue area perimeter bores and regional bores. These bores are routinely monitored and the results are reported to the DEC and DoW annually in accordance with licence conditions.

7.9.4 Guiding Principles and Alcoa’s Commitments

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

Guiding Principle: Management Strategy
Alcoa shall develop and implement a groundwater management strategy that includes the resources required to plan for groundwater recovery and post closure management.

Alcoa’s Response
Alcoa implements an existing groundwater management strategy which is reviewed on a regular basis. Groundwater management post closure of the refinery will be agreed with government at the time of closure.

Guiding Principle: Monitoring
Alcoa shall continue to monitor and report on the extent of groundwater impact and contamination from the bauxite residue drying areas.

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

Guiding Principle: Private Bore Sampling
Alcoa shall continue to sample and analyse agreed private property groundwater bores and rain water tanks. This sampling shall occur during autumn every two years.

Alcoa’s Response
Alcoa accepts and agrees with this principle. Alcoa will undertake sampling for relevant parameters upon request from agreed near neighbours. This sampling will be undertaken in autumn every two years.

7.10 Land Use Management and Visual Amenity

7.10.1 Background
Due to the relatively undulating terrain surrounding the Kwinana residue area and the volume of residue to be stored, the residue impoundments are a prominent feature on the local landscape. As population densities have increased in the immediate surrounds and with transport routes such as the Kwinana Freeway now passing approximately one kilometre to the east, visual amenity is of increasing importance. The Kwinana Residue SRG raised visual amenity as an important aspect in ongoing residue management.
During 2004 a Viewshed Analysis was conducted of the Kwinana residue area to define from where and to what extent the residue area is visible. This data is now used to inform visual amenity plans. 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 Alcoa’s 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 7-6.

### 7.10.2 Current Management Strategies

A land management program at Kwinana Refinery has been ongoing for the past 15 years. The focus of Alcoa’s visual amenity efforts is on the rehabilitation of external residue embankments which are increasingly visible as the height of the residue storage areas increases. However landscape planting along roadsides is used to complement the rehabilitation program in high priority areas. Figure 7-7 shows the residue embankment from Anketell Road.

Residue rehabilitation programs are outlined in Section 7.11

### 7.10.3 Visual Amenity Guiding Principles and Alcoa’s Commitments

In response to the information provided, the Kwinana 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 prepare and regularly update the visual amenity plan.*

**Alcoa’s Response**

Alcoa accepts and agrees with this principle. Alcoa will develop and regularly update a visual amenity plan that will include progressive embankment rehabilitation and explore options for visual screening along existing and proposed major travel routes adjacent to the residue areas.

### 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 Kwinana 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.

Kwinana’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 7-8) 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 7-8). 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 7-8). 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 7-8). 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 on residue embankments can be seen in Figure 7-9.

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...
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Stage 1:
Gypsum incorporation
Gypsum for soil improvement
(225 t/ha to 1.5 m depth)

Stage 2:
Fertiliser incorporation
DAP-based fertiliser for nutrient supply
(2.7 t/ha to 0.2 m depth)

Stage 3:
Seeding and mulching for dust control and protection of seedlings
Seeding
(2-3 kg/ha of native coastal species)
Woodmulch (600 m3/ha or 30 mm depth)

Stage 4:
Tube stock planting
Planting density
(approx. 1200 stems/ha; species not able to be grown from seed)

Current Vegetation target
Performance assessed through botanical monitoring

Figure 7-8: Residue rehabilitation process.

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.
1. Improve the visual amenity of the external embankments;
2. Prevent the generation of dust; and
3. Enhance the conservation value of the area.

Alcoa will investigate opportunities to utilise topsoil from nearby residential developments.

**Guiding Principle: Priority**
Residue rehabilitation for new and existing areas is to improve visual amenity, reduce dust lift off and contain any offsite impact during and after rehabilitation. As a priority the rehabilitation should be self sustaining in the long term. As part of this guiding principle, Alcoa to look for opportunities to utilise topsoil from nearby residential developments and develop synergies with those developments.

**Alcoa’s Response**
Alcoa aims to minimise any offsite impacts from its operations. The primary objectives for residue rehabilitation are:

**Guiding Principle: Prescription**
Alcoa to continue developing its rehabilitation prescription with a focus on maximising establishment of groundcovers to assist with dust control. Native and locally indigenous species should be used where suitable.

**Alcoa’s Response**
Alcoa accepts and agrees with this principle.
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 (five to seven 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 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.

This 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 2037); 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:

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

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 of new residue areas are required. To do this, Alcoa is trialling alternative amphirling 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/acylate mixture that is chemically equivalent to the flocculants currently used in the super-thicker. 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 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 Kwinana Refinery’s residue area, this could have a number of advantages:

- Residue operations could be sustained within the current footprint for approximately the next 15 years;
- Residue water use would be significantly reduced;
- Reduced potential to produce dust from the drying areas; and
- Reduced potential to impact groundwater.

Press filters are already being successfully used in a number of industries around the world with high production rates. 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 Residue Storage Techniques
Guiding Principles
In response to the information provided, the Kwinana LTRMS SRG developed one guiding principle relating to the footprint reduction opportunities. This is presented below, together with Alcoa’s response.

Guiding Principle
Alcoa will continue to investigate alternate technologies and processes that will enable a reduction in required residue drying area and dust emissions.

Alcoa’s Response
Alcoa accepts and agrees with this principle. Opportunities for reducing required drying area and the potential for dust emissions will be investigated and assessed for their applicability, effectiveness, cost and benefit to Alcoa’s Kwinana operations.

8.4 Residue Area Planning
Considerations
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.

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.

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.

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

Table 8-1: Sustainability criteria used to assess footprint options.
Water storage is considered to be a temporary land use as when the refinery closes, the water storage ponds can be fully decommissioned and the land can then be made available for other uses. Relocation of the water storage ponds outside of the existing residue footprint will facilitate the consolidation of the existing residue area footprint.

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 framework, as outlined in Table 8-1. A summary of this assessment for each option is presented below.

**Northern Expansion**

Alcoa does not consider northerly expansion of the residue area a preferable option. While expansion directly to the north of the existing residue area would allow for a new residue drying area to adjoin the existing stack, there are neighbouring residential properties and major power line infrastructure located in the vicinity.

**Southern Expansion**

Alcoa does not consider expansion of the current residue storage area to the south as a preferable option. However, Alcoa does currently consider the south option to be feasible for the future relocation of the water storage facilities.

Figure 8-1: Proposed locations for future water storage facilities.
Water storage activities have minimal impact on near neighbours and Alcoa believes that the potential impacts from these areas can be effectively managed.

**Western Expansion**
Alcoa does not consider expansion of the current residue area to the west as a preferable option, due to the presence of wetlands, Abercrombie Road and a major gas pipeline.

**East Expansion**
Alcoa does not consider expansion of the current residue area to the east as a preferable option, due to the proximity to neighbours and the location of the Bush Forever site.

**North West Expansion**
During discussions of future residue expansion options, the SRG identified an additional potential option for the relocation of water storage facilities to the North West, to a site currently occupied by a quarry. The location of this area is shown in Figure 8-1. Alcoa will investigate this option and assess its feasibility.

### 8.4.4 Residue Area Planning

**Guiding Principles**
In response to the information provided, the Kwinana LTRMS SRG developed six guiding principles relating to the life-of-mine construction strategy. These are presented below, together with Alcoa's response.

**Guiding Principle**
The SRG recognises that the life-of-mine footprint is based on a maximum stack height of RL 80 m.

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

**Guiding Principle: Regional Planning**
The SRG encourages Alcoa to continue working with relevant Local and State government authorities to ensure the future management of the RSA is consistent with the future land use and development of surrounding properties as per the strategic planning framework and the reasonable expectations of landholders.

Alcoa's Response
Alcoa believes government is responsible for ensuring land use zoning in areas adjacent to existing and future industries in the Kwinana Industrial Area is consistent with the State Industrial Buffer Policy and compatible with heavy industry.

Alcoa will continue working with local and state government authorities to ensure planning decisions are based on the best information available.

**Guiding Principle: Kwinana Industrial Buffer**
The State Government is responsible for determining the Kwinana Industrial Buffer. Alcoa agrees the Kwinana Industrial Buffer should be finalised to provide certainty for all land holders.

Alcoa's Response

**Guiding Principle: Kwinana Industrial Buffer**
Should a buffer zone be declared (and acknowledged by Alcoa), residents inside the Kwinana Industrial Buffer be given the option that Alcoa is to purchase their land at market value at time of declaration.

Alcoa's Response
Alcoa will abide by the land use boundaries implemented by the WAPC, Department of Planning and the City of Kwinana. Alcoa will only purchase land in the area around its residue operations for future residue infrastructure.

**Guiding Principle: Constraints**
Land outside any declared buffer will be free of constraints imposed by the operations of Alcoa.

Alcoa's Response

**Guiding Principle: Constraints**

It is acknowledged that increased stack heights are likely to be more visible than lower stack height options, and may provide greater challenges for dust management. However previous SRGs supported the principle of increased stack heights so long as management of these issues continued to improve. The current SRG supported final stack heights of up to RL 80 meters for the final residue landform.

Alcoa's Response

The LTRMS document is designed to inform local and State governments and the wider community of Alcoa's long term strategies and commitments for a sustainable future in 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 residue at Kwinana Refinery. This document is submitted to government to facilitate planning processes that consider Alcoa’s residue areas.

Alcoa’s Response

Alcoa of Australia Limited
8.5 Life-of-Mine Construction Strategy (2045)

Alcoa plans to acquire additional land and relocate the water storage facilities in the future to allow the residue stack to be consolidated. By consolidating the existing drying area, separation of the residue drying area from neighbouring landholders can be maximised. The water storage facilities are temporary land use and can be effectively decommissioned following closure of the refinery, leaving the land available for other land uses.

Options for the location of the new water storage facilities are still to be identified and thoroughly investigated against sustainability principles, however the current preferred option is to the south of the current residue area, near the existing Cooling Ponds. During the development of the LTRMS, the SRG suggested an alternative area for the water storage facilities to the northwest of the existing footprint, at the location of an existing quarry. Alcoa will investigate this option and assess its feasibility.

Potential locations for the new water storage facilities are shown on Figure 8-1. Further options identification, analysis, detailed design and site investigations are still to be completed to determine the location and exact size of the ponds, and land will need to be acquired for the facility.

Land for the future water storage facilities will need to be appropriately zoned and rezoning applications will likely be required. Further information on the relocation of the water storage facilities can be found in the Mid-Term Construction Strategy, Section 8.6.3.

As long as timely acquisition and rezoning of land can be achieved for the new water storage facilities, Alcoa currently has sufficient appropriately zoned land to provide storage areas for the life-of-mine, at current planned production rates.

8.6 Mid-Term Construction Strategy (25 years)

The key construction issues to be managed within the mid-term 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, 130 hectares of additional drying area is required. Projects designed to provide 60 hectares of the 130 hectares drying area required are currently planned to be constructed between 2012 and 2019, and are presented in Sections 8.3.

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.

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. The existing Area H has beach-like areas where the water continuously wets the dried residue. The dry residue areas within this RSA cannot be safely accessed with machinery to install and maintain sprinkler systems similar to those on the dry stacked RSAs, making dust management in this area challenging. Lateral sprinklers are currently used to cover as much of this area as possible.

Conversion of this area to dry stacking will allow the same effective dust management strategies and sprinkler networks currently employed on the existing dry stacked areas to be used. Alcoa believes this will lead to improved dust management of the residue area as a whole.

8.6.1 Conversion of Area H to Dry Stacking

The existing wet storage Area H is planned for future conversion to dry stacking. Conversion of this area to dry stacking will have a number of benefits including more efficient use of the drying area, improved dust management and reduced risk of groundwater contamination. The current Area H is shown in Figure 8-2.

Conversion of this area to dry stacking is likely to require the development of an alternative water storage pond outside of the existing footprint, to allow for consolidation of the existing residue area. The relocation of the water storage facilities is discussed in section 8.6.3.
8.6.2 Super-thickener Relocation
The super-thickener is currently located in the middle of the Kwinana residue area. Alcoa currently plans to relocate this super-thickener at some stage in the future, to another location within the existing residue footprint. This would allow the area currently occupied by the super-thickener to be used for residue storage, consolidating the residue drying area. See Figure 8-1 for the current location of the super-thickener.

8.6.3 Relocation of Water Storage Facilities
If Area H and the existing ROWS Pond, which are located in the current drying area footprint, are converted to dry stacking, new water storage facilities will need to be built.

The ROWS Pond currently provides storage for groundwater from licensed abstraction bores, good quality condensate from the refinery and make-up water purchased from the Water Corporation. Water stored in this reservoir is predominately used for dust control at the residue area and as cooling water in the refinery. The current ROWS Pond is shown in Figure 8-3.

Alcoa plans to acquire additional land and relocate the water storage facilities in the future to allow the residue stack to be consolidated. See Figure 8-1 for the current potential locations for these facilities.

8.6.4 Greenfield Residue Development Options
Although the range of possible future drying areas required for the next 25 years has been determined, the actual footprint for these areas will be determined in response to further studies of the area. A more detailed sequencing of residue areas should be possible in the next five yearly LTRMS review.

It must be noted that the rate at which the mid-term drying area footprint is consumed will be a function of the same constraints discussed in Section 8.2, in addition to the following variables:

- design stack height;
- residue reuse commercialisation opportunities; and
- ability to locate the water storage ponds outside of the mid-term drying area footprint in the required timeframe.

8.6.5 Mid-Term Construction Strategy Guiding Principles
In response to the information provided, the Kwinana LTRMS SRG developed four guiding principles relating to the mid-term construction strategy.
Guiding Principle: Future Plans
The SRG acknowledges Alcoa’s future residue area development options to maximise the efficient use of the existing rezoned residue area footprint for residue storage:
- Construction of Area O;
- Construction of Area P;
- Conversion of H Lake to dry storage subject to this not increasing dust emissions, noting the proximity of H Lake to existing and future sensitive development;
- Relocation of the super thickener and associated infrastructure and conversion of this area to dry storage;
- Construction of a new ROWS pond; and
- Conversion of the current ROWS pond to dry storage.

Alcoa's Response
Alcoa accepts and agrees with this principle. As part of the consultation process, Alcoa presented the current footprint development plans and approximate planned development dates to the SRG. Construction plans, including timelines, are subject to change due to various factors including economic, operational, and regulatory impacts.

Alcoa believes that dust management of dry stacked residue areas is more effective than dust management of wet lake areas, due to the ability to install sprinkler networks on dry stacked residue areas. This cannot be achieved on the beaches of wet lake areas due to inaccessibility.

Guiding Principle: Assessment Criteria
Alcoa to include in the LTRMS document the criteria used to assess the feasibility of new residue drying areas options and the current proposed construction schedule for the 25 year plan.

Alcoa's Response
Alcoa accepts and agrees with this principle. These are included in Section 8.4.1.

Guiding Principle: Water Storage Location
The SRG supports Alcoa’s strategy to pursue options to relocate its water storage facilities outside of the residue drying footprint in consultation with the relevant local governments. Preferred location is the existing quarry operations, to the north of Area P.

Alcoa's Response
Alcoa accepts and agrees with this principle with the exception of the preferred location. Alcoa notes that the City of Kwinana’s preferred location is the existing quarry operations, to the north of Area P. Alcoa will investigate this option and consider it as a potential option in addition to Alcoa’s current preferred option of areas near the existing Cooling Pond.

Guiding Principle: Minimise Open Drying Area
Alcoa to pursue a residue storage strategy that minimises active open drying area.

Alcoa's Response
Alcoa maintains the minimum open drying area that is sufficient to dry residue mud to the required stack strength. Achieving the required stack strength is essential to ensure the efficient use of the residue footprint.

8.7 Short-Term Construction Strategy (5-7 years)
Key issues to be managed within the short-term strategy 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.

8.7.1 Business as Usual
Construction Activities
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 pipe work;
- extension/modification of mud and sand distribution pipe work;
- 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 Closure of Area F
As outlined in the 2005 Kwinana LTRMS document, Alcoa is currently implementing plans to close and rehabilitate Area F. To date, significant progress has been made to cap and rehabilitate the area; currently, only 19% of the original drying area remains open.
For the remainder of Area F to be closed, Area O and its associated Runoff Collection Pond (ROCP) must be constructed and commissioned to continue to provide the required drying area for Kwinana Refinery. The Area O project has been in development for a number of years and, to date, significant progress has been made in gaining the necessary approvals.

In 2003, Alcoa first applied to rezone the area required for RSAs N, O and P. The proposal was declined at that time, pending the outcome of the 2005 LTRMS process. An application was then submitted to rezone Areas N, O and P in July 2006 however it was withdrawn and a separate application was submitted for the Area N portion only in July 2007 due to concerns that resolution of issues relating to the closure of Postana Road would cause unacceptable delays to this project.

Alcoa applied to rezone Areas O and P in September 2008 and required the Scheme Amendment adoption by December 2009 in order to progress the early closure of Area F. The rezoning application was approved on 29 March 2011.

Now that the rezoning for Areas O and P has been approved, Alcoa is applying for internal funding to construct these two new drying areas and approval from the necessary government agencies to undertake clearing and construction.

At the time of publication of this LTRMS document, Area O is expected to be commissioned at the end of 2015, and the ROCP in 2016. The process to close the remainder of Area F will commence once these areas are commissioned.

8.7.3 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 continue implementing the plans to close Area F, and provide new drying areas for current production rates through construction of two new drying areas, Area O and Area P. Area O and Area P will be constructed on Alcoa owned land within the Rural B zoned area to the west of the current areas, providing approximately 60 hectares of drying area.

In addition to the development of Area O and Area P, Alcoa is currently giving consideration to partially converting the existing wet storage Area H to dry stacking, and developing a new surge pond within the existing Area N during the period 2012-2019.

8.7.3.1 Area O
The project planning phase for Area O is currently underway. Area O will be built on land owned by Alcoa, in accordance with Alcoa’s latest standards for drying areas which comply with relevant regulatory requirements. For example, Area O will be built with:

- 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 nominal location of Area O is shown in Figure 8-1.

Construction of Area O is currently planned to commence in 2013 with commissioning planned for 2015. These timeframes are subject to the constraints outlined in Section 8.2.

8.7.3.2 Area P
Alcoa plans to construct Area P once Area O is complete. This is subject to the constraints outlined in Section 8.2.

Area P 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 Area P is shown in Figure 8-1.

8.7.3.3 Partial Conversion of Area H to Dry Stacking
As part of Alcoa’s mid-term residue construction strategy, Alcoa plans to
To meet the requirements of the current mid-term construction strategy, Alcoa will need to acquire additional land for the relocation of the water storage facilities. This land will subsequently need to be rezoned to “Rural B” under the Kwinana Town Planning Scheme.

With the exception of additional land required for the relocated water storage facilities, Alcoa currently has sufficient appropriately zoned land to provide storage areas for the life-of-mine, at current planned production rates.

8.7.4 Short-Term Construction Strategy Guiding Principles
In response to the information provided, the Kwinana LTRMS SRG developed one guiding principle relating to the short-term construction strategy.

Guiding Principle
The SRG acknowledges Alcoa’s short-term footprint development plans to maximise the efficient use of the existing rezoned residue area footprint for residue storage:
- Construction of Area O;
- Construction of Area P; and
- Closure of Area F.

Alcoa’s Response
Alcoa accepts and agrees with this principle. As part of the consultation process, Alcoa presented the current footprint development plans and approximate planned development dates to the SRG. Construction plans, including timelines, are subject to change due to various factors including economic, operational, and regulatory impacts.

8.8 Planning Strategy to Support Future Residue Development Requirements
Alcoa’s application to rezone the land required for Areas O and P was approved on 29 March 2011.

To meet the requirements of the current mid-term construction strategy, Alcoa will need to acquire additional land for the relocation of the water storage facilities. This land will subsequently need to be rezoned to “Rural B” under the Kwinana Town Planning Scheme.

With the exception of additional land required for the relocated water storage facilities, Alcoa currently has sufficient appropriately zoned land to provide storage areas for the life-of-mine, at current planned production rates.
9 Residue Closure and Rehabilitation

At closure, many of the impacts arising during operations will no longer be significant, for example dust generation and water use. Key additional considerations at closure relate to the final form of the residue area, management of contaminated stormwater, management of leachate and final land use. This section outlines the key issues discussed with the Kwinana LTRMS SRG for closure.

The process of defining the closure strategy will be ongoing. Final closure of the Kwinana 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.

The State Agreement Act (1961) states that each closed residue area must be able to support light industry.

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
- 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 release, or reuse through other industries, once the refinery has closed.

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 and 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. For example:

- A green belt between industrial and residential land uses;
- Light industry;
- Community recreational facilities such as playing fields; and
- Passive recreation (such as walking trails).

An example of final land use is Area ABC 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, 2005a). 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 Kwinana LTRMS SRG developed two guiding principles relating to closure. These are presented below, together with Alcoa’s response.

Guiding Principle: Water Treatment
Alcoa shall assess the relevant options for treatment and reuse or discharge of alkaline drainage water post closure in consultation with the community.

Alcoa’s Response
Alcoa accepts and agrees with this principle. Alcoa will continue with reuse of alkaline drainage water within the Kwinana Refinery. Options for treatment of alkaline water for discharge will be assessed as the refinery approaches closure.

Guiding Principle: Future Land Use
Alcoa to investigate future land uses that could be suitable for location on closed residue storage areas and prepare a rehabilitation plan for consultation with relevant government agencies and other key stakeholders. Alcoa should ensure that this is investigated in the context of the current and planned strategic planning frameworks.

Alcoa’s Response
Alcoa prepares rehabilitation and closure plans in accordance with the State Agreement Act and other government requirements.

As residue areas are closed, potential uses for those areas will be investigated and Alcoa will consult with relevant stakeholders at that time.

The closure strategy for the residue areas continues to be developed. This information will be included in future LTRMS reviews.
10.1 Summary of Guiding Principles and Alcoa’s Response

The Kwinana 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.

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>SRG’s Guiding Principle</th>
<th>Alcoa’s Response</th>
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<tbody>
<tr>
<td><strong>EDUCATION</strong></td>
<td></td>
</tr>
<tr>
<td>Alcoa shall implement processes that assist in educating the community about the improvements that have been achieved and about the practicalities of Alumina refining, Bauxite residue management.</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td><strong>RESIDUE REUSE</strong></td>
<td></td>
</tr>
<tr>
<td>a) Alternative Uses</td>
<td>Alcoa will continue to pursue safe alternative uses of residue. Each potential use will be assessed for feasibility on a case-by-case basis.</td>
</tr>
<tr>
<td>Alcoa to continue actively pursuing safe alternative uses of residue.</td>
<td></td>
</tr>
<tr>
<td>b) Research</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td>Alcoa to utilise existing residue reuse trial sites for monitoring and evaluation purposes.</td>
<td></td>
</tr>
<tr>
<td>c) Education</td>
<td>Alcoa currently seeks relevant opportunities to educate stakeholders about the safety and potential benefits of residue products. This will be continued in the future.</td>
</tr>
<tr>
<td>Alcoa to develop and implement an ongoing program to educate the general public about the safety and potential benefits of residue products.</td>
<td></td>
</tr>
<tr>
<td>d) Product Approval</td>
<td>Where relevant, Alcoa will share the approvals process we follow for residue reuse products, subject to commercial confidentiality considerations.</td>
</tr>
<tr>
<td>Alcoa to document the approvals pathway that it follows for approval of residue reuse products, identifying barriers and success points for future learning and share the information as appropriate.</td>
<td></td>
</tr>
<tr>
<td>e) Reporting</td>
<td>Alcoa accepts and agrees with this principle.</td>
</tr>
<tr>
<td>Alcoa to report annually on the status of research into residue re-use, including the status of any approvals required for its use.</td>
<td></td>
</tr>
<tr>
<td>SRG’s Guiding Principle</td>
<td>Alcoa’s Response</td>
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<td>-------------------------------------------------------------</td>
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</tr>
<tr>
<td><strong>FLORA AND FAUNA</strong></td>
<td></td>
</tr>
<tr>
<td>Alcoa shall continue the triennial assessment programs for</td>
<td>Alcoa will continue triennial flora and fauna assessments. The focus of the assessments will be continuously reviewed and adapted where appropriate. Alcoa will continue to develop and implement land management programs on an annual basis.</td>
</tr>
<tr>
<td>Flora, Fauna and Land Management.</td>
<td></td>
</tr>
<tr>
<td><strong>HERITAGE</strong></td>
<td></td>
</tr>
<tr>
<td>Alcoa shall continue to work towards protecting Aboriginal</td>
<td>Alcoa will continue to survey for Aboriginal and European heritage sites within the footprint of new residue areas, and where applicable, will develop management plans for those sites.</td>
</tr>
<tr>
<td>and European heritage.</td>
<td></td>
</tr>
<tr>
<td><strong>HYDROLOGY</strong></td>
<td></td>
</tr>
<tr>
<td>Alcoa shall continue its emphasis on wetland research</td>
<td>Alcoa will continue its six monthly water sampling program at Wellard and will develop and implement ongoing land management programs for wetland areas located on its land. Alcoa will include the Wellard wetlands in the triennial fauna assessment on a periodic basis.</td>
</tr>
<tr>
<td>through tertiary education sponsorship and the ongoing land</td>
<td>Alcoa has previously sponsored a range of wetland research programs. At this time Alcoa does not see the need for further research.</td>
</tr>
<tr>
<td>management program.</td>
<td></td>
</tr>
<tr>
<td><strong>DUST</strong></td>
<td></td>
</tr>
<tr>
<td>a) Control and Improvement</td>
<td>Alcoa is committed to its dust management program and continues to seek improvement of dust control measures. In addition, Alcoa will continue to evaluate new dust control measures as they become available.</td>
</tr>
<tr>
<td>Alcoa to research and implement improved methods of dust</td>
<td></td>
</tr>
<tr>
<td>control with the objective of eliminating offsite dust</td>
<td></td>
</tr>
<tr>
<td>impacts.</td>
<td></td>
</tr>
<tr>
<td>b) Education</td>
<td>Alcoa currently seeks relevant opportunities to disseminate information to stakeholders to assist them to understand how dust is measured, relevant dust standards and levels of compliance. These initiatives include Alcoa’s Environmental Improvement Plan (EIP) process and the Kwinana Community Industry Forum. This will be continued in the future.</td>
</tr>
<tr>
<td>Alcoa to develop initiatives and disseminate information</td>
<td></td>
</tr>
<tr>
<td>that assists the community to understand how dust is measured, relevant dust standards and levels of compliance.</td>
<td></td>
</tr>
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</table>

Alcoa is committed to its dust management program and continues to seek improvement of dust control measures. In addition, Alcoa will continue to evaluate new dust control measures as they become available.
### SRG’s Guiding Principle

<table>
<thead>
<tr>
<th>Alcoa’s Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcoa’s dust monitoring programme is reviewed and updated annually. Alcoa will continue to monitor dust in accordance with DEC licence conditions and in consultation with the EIP working group, to whom it regularly reports on the effectiveness of dust management strategies.</td>
</tr>
<tr>
<td>Alcoa recently undertook a study on radiation exposure for its WA Operations, including residue. This study found exposures were below relevant Australian standards. Should Alcoa’s processes change significantly in the future, Alcoa will review the study to reassess exposure levels.</td>
</tr>
<tr>
<td>In addition, Alcoa has completed a comprehensive Health Risk Assessment (HRA) to assess ground level concentrations of compounds against relevant national and international health guidelines. The full report is available online at: <a href="http://www.alcoa.com/australia/en/pdf/HRA_Pinjarra_Dust_21_August_08.pdf">http://www.alcoa.com/australia/en/pdf/HRA_Pinjarra_Dust_21_August_08.pdf</a></td>
</tr>
</tbody>
</table>

### c) Monitoring

Alcoa shall develop a clear long term dust monitoring plan in consultation with the community and the DEC to evaluate:

1. Dust impacts
2. Radiation levels from dust
3. Health impacts from dust and
4. The success of dust management strategies.

Alcoa believes the current number and location of dust monitors is adequate.

The location of licensed dust monitors is regularly reviewed by Alcoa and the DEC. Where opportunities for improvement are identified, monitors are relocated e.g. the Mortimer Farm/Residue West monitor was relocated recently.

In addition, Alcoa operates a number non-licensed dust monitors to further assist with dust management strategies.

Dust monitor locations are determined based on the following:

- Approval by the DEC;
- Potential for impacts from other sources and land uses (must be minimal);
- Approval by the owners of the land where the monitors are situated;
- Accessibility by Alcoa personnel (Alcoa must have full access rights);
- Availability of power;
- Clearance from vegetation;
- Suitability of topography; and
- Compliance with relevant Australian Standards.

### d) Monitor Locations

Alcoa to change the location and the number of dust monitors to ensure that dust monitoring occurs near existing and planned residential development. This is to help focus on the areas for improvement as part of dust management in the RSA.

Alcoa operates a number non-licensed dust monitors to further assist with dust management strategies.

Dust monitor locations are determined based on the following:

- Approval by the DEC;
- Potential for impacts from other sources and land uses (must be minimal);
- Approval by the owners of the land where the monitors are situated;
- Accessibility by Alcoa personnel (Alcoa must have full access rights);
- Availability of power;
- Clearance from vegetation;
- Suitability of topography; and
- Compliance with relevant Australian Standards.
<table>
<thead>
<tr>
<th>SRG's Guiding Principle</th>
<th>Alcoa's Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>e) Access to Data</td>
<td>Alcoa believes the current level of dust monitoring reporting is adequate.</td>
</tr>
<tr>
<td></td>
<td>Alcoa investigates and reports dust complaints and dust limit exceedances to the DEC, in accordance with the DEC licence. When a complaint is received, the community member is offered the opportunity to discuss the findings of the investigation.</td>
</tr>
<tr>
<td></td>
<td>In addition, Alcoa currently reports dust monitoring data, which includes the total dust levels from both Alcoa and non-Alcoa sources, to the EIP working group on a quarterly basis.</td>
</tr>
</tbody>
</table>

**ODOUR & VOCS**

| Alcoa to characterise the odour from the RSA and assess the impact of odour on the community. | In 2004, odour and Volatile Organic Compound (VOC) emissions from various residue sources at Alcoa's Wagerup Refinery were measured directly for the first time. This study was submitted to the DEC as part of the environmental assessment for the approved Wagerup Unit Three expansion. 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. The study concluded that odour emissions from residue areas are not regarded as significant. These findings are applicable to the Kwinana Refinery and Alcoa believes that further research would not alter these conclusions. |

**RADIATION & HEALTH**

| Alcoa shall continue the radiation monitoring program and regularly report to the relevant government agencies and the community. | The International Atomic Energy Agency recently developed guidelines on the management of materials that contain naturally occurring radioactive material. Australia has adopted these guidelines, which require materials with radiation levels above 1Bq/g to be subject to specific monitoring and reporting. The State Government is yet to implement these guidelines. Alcoa conducted an assessment of Naturally Occurring Radioactive Materials across all of its WA locations. Alcoa is currently finalising the report on this assessment which will be submitted to the Radiation Council of WA. The assessments showed that all results were below Australian public exposure standards. As the study found Alcoa's workforce exposure is less than Australian public exposure standards, Alcoa will request an exemption to these guidelines so that ongoing monitoring is not required. The assessments concluded that exposure to the community is lower than the exposure to the workforce. |
### SRG’s Guiding Principle

### WATER USE

The RSA to utilise treated water from the Kwinana Wastewater Treatment Plant (on McLaughlan Rd) for all non-potable needs.

Alcoa will continue to conserve water through reuse and reduction initiatives, and identification of alternative sources. Alcoa is currently progressing a project with the Water Corporation to reuse water from the Kwinana Wastewater Treatment Plant. This is subject to regulatory support and approval. The volume of treated wastewater obtained under this project is limited and will not be sufficient to replace all non-potable water needs, and the water will not be suitable for all non-potable water uses.

### GROUNDWATER

#### a) Water Treatment

Alcoa shall assess the relevant options for treatment and reuse or discharge of alkaline drainage water post closure in consultation with the community.

Alcoa accepts and agrees with this principle. Alcoa will continue with reuse of alkaline drainage water within the Kwinana Refinery. Options for treatment of alkaline water for discharge will be assessed as the refinery approaches closure.

#### b) Management Strategy

Alcoa shall develop and implement a groundwater management strategy that includes the resources required to plan for groundwater recovery and post closure management.

Alcoa implements an existing groundwater management strategy which is reviewed on a regular basis. Groundwater management post closure of the refinery will be agreed with government at the time of closure.

#### c) Monitoring

Alcoa shall continue to monitor and report on the extent of groundwater impact and contamination from the Bauxite Residue Drying Areas.

Alcoa accepts and agrees with this principle.

#### d) Private Bore Sampling

Alcoa shall continue to sample and analyse agreed private property groundwater bores and rain water tanks. This sampling shall occur during autumn each two years.

Alcoa accepts and agrees with this principle. Alcoa will undertake sampling for relevant parameters upon request from agreed near neighbours. This sampling will be undertaken in autumn every two years.

### LAND USE MANAGEMENT & VISUAL AMENITY

#### a) Visual Amenity Plan

Alcoa to prepare and regularly update the visual amenity plan.

Alcoa accepts and agrees with this principle. Alcoa will develop and regularly update a visual amenity plan that will include progressive embankment rehabilitation and explore options for visual screening along existing and proposed major travel routes adjacent to the residue areas.

#### b) Visual Modelling

Alcoa to undertake a new visual modelling exercise which seeks to promote the RSA ultimately appearing as a natural legacy on the landscape. The final form of this model is to inform future design and/or residue storage practices.

Alcoa has previously completed visual amenity studies. Alcoa does not believe that a new modelling study is warranted at this time as the findings of the previous studies are still relevant.
### RESIDUE AREA REHABILITATION

**a) Priority**
Residue Rehabilitation for new and existing areas is to improve visual amenity, reduce dust lift off and contain any offsite impact during and after rehabilitation. As a priority the rehabilitation should be self sustaining in the long term. As part of this Guiding Principle, Alcoa to look for opportunities to utilise topsoil from nearby residential developments and develop synergies with those developments.

Alcoa aims to minimise any offsite impacts from its operations. The primary objectives for residue rehabilitation are:
1. Improve the visual amenity of the external embankments;
2. Prevent the generation of dust; and
3. Enhance the conservation value of the area.

Alcoa will investigate opportunities to utilise topsoil from nearby residential developments.

**b) Prescription**
Alcoa to continue developing its rehabilitation prescription with a focus on maximising establishment of groundcovers to assist with dust control. Native and locally indigenous species should be used where suitable.

Alcoa accepts and agrees with this principle.

### FOOTPRINT DEVELOPMENT (5-7 YRS)

The SRG acknowledges Alcoa’s short-term footprint development plans to maximise the efficient use of the existing rezoned residue area footprint for residue storage:

- Construction of Area O;
- Construction of Area P; and
- Closure of Area F.

Alcoa accepts and agrees with this principle. As part of the consultation process, Alcoa presented the current footprint development plans and approximate planned development dates to the SRG. Construction plans, including timelines, are subject to change due to various factors including economic, operational, and regulatory impacts.

### FOOTPRINT DEVELOPMENT (25 YRS)

**a) Future Plans**
The SRG acknowledges Alcoa’s future residue area development options to maximise the efficient use of the existing rezoned residue area footprint for residue storage:

- Construction of Area O.
- Construction of Area P.
- Conversion of H Lake to dry storage subject to this not increasing dust emissions, noting the proximity of H Lake to existing and future sensitive development.
- Relocation of the super thickener and associated infrastructure and conversion of this area to dry storage.
- Construction of a new ROWS pond.
- Conversion of the current ROWS pond to dry storage.

Alcoa accepts and agrees with this principle. As part of the consultation process, Alcoa presented the current footprint development plans and approximate planned development dates to the SRG. Construction plans, including timelines, are subject to change due to various factors including economic, operational, and regulatory impacts.

Alcoa believes that dust management of dry stacked residue areas is more effective than dust management of wet lake areas, due to the ability to install sprinkler networks on dry stacked residue areas. This cannot be achieved on the beaches of wet lake areas due to inaccessibility.

**b) Assessment Criteria**
Alcoa to include in the LTRMS document the criteria used to assess the feasibility of new residue drying areas options and the current proposed construction schedule for the 25 year plan.

Alcoa accepts and agrees with this principle.
<table>
<thead>
<tr>
<th>SRG’s Guiding Principle</th>
<th>Alcoa’s Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>c) Water Storage Location</strong>&lt;br&gt;The SRG supports Alcoa’s strategy to pursue options to relocate its water storage facilities outside of the residue drying footprint in consultation with the relevant local governments. Preferred location is the existing quarry operations, to the north of Area P.</td>
<td>Alcoa accepts and agrees with this principle with the exception of the preferred location. Alcoa notes that the Town of Kwinana’s preferred location is the existing quarry operations, to the north of Area P. Alcoa will investigate this option and consider it as a potential option in addition to Alcoa’s current preferred option of areas near the existing Cooling Pond.</td>
</tr>
<tr>
<td><strong>d) Minimise Open Drying Area</strong>&lt;br&gt;Alcoa to pursue a residue storage strategy that minimises active open drying area.</td>
<td>Alcoa maintains the minimum open drying area that is sufficient to dry residue mud to the required stack strength. Achieving the required stack strength is essential to ensure the efficient use of the residue footprint.</td>
</tr>
</tbody>
</table>

**FOOTPRINT REDUCTION OPPORTUNITIES**

- Alcoa to continue to investigate alternate technologies and processes that will enable a reduction in required residue drying area and dust emissions.<br>  
- Alcoa accepts and agrees with this principle. Opportunities for reducing required drying area and the potential for dust emissions will be investigated and assessed for their applicability, effectiveness, cost and benefit to Kwinana’s operations.

**HEIGHT**

- The SRG recognises that the life of mine footprint is based on a maximum stack height of RL 80 m.<br>  
- Alcoa accepts and agrees with this principle.

**LAND USE PLANNING**

- **a) Regional Planning**<br>The SRG encourages Alcoa to continue working with relevant Local and State government authorities to ensure the future management of the RSA is consistent with the future land use and development of surrounding properties as per the strategic planning framework and the reasonable expectations of landholders.<br>  
- Alcoa believes government is responsible for ensuring land use zoning in areas adjacent to existing and future industries in the Kwinana Industrial Area is consistent with the State Industrial Buffer Policy and compatible with heavy industry.<br>  
- Alcoa will continue working with local and state government authorities to ensure planning decisions are based on the best information available.

- **b) Regional Planning**<br>The LTRMS needs to be clear, certain and applicable in all planning processes.<br>  
- The LTRMS document is designed to inform local and State governments and the wider community of Alcoa’s long term strategies and commitments for a sustainable future in 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 residue at Kwinana Refinery. This document is submitted to government to facilitate planning processes that consider Alcoa’s residue areas.

- **c) Kwinana Industrial Buffer**<br>The State Government as a matter of urgency should determine the final Kwinana Industrial Buffer for the RSA in consultation with relevant stakeholders. This should be implemented through the WAPC under the Planning and Development Act (2005) or by the EPA under s16 of the EP Act (1986).<br>  
- The State Government is responsible for determining the Kwinana Industrial Buffer. Alcoa agrees the Kwinana Industrial Buffer should be finalised to provide certainty for all land holders.
<table>
<thead>
<tr>
<th>SRG's Guiding Principle</th>
<th>Alcoa's Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>d) Kwinana Industrial Buffer</td>
<td>Should a buffer zone be declared (and acknowledged by Alcoa), residents inside the Kwinana Industrial Buffer be given the option that Alcoa is to purchase their land at market value at time of declaration.</td>
</tr>
<tr>
<td></td>
<td>Alcoa will abide by the land use boundaries implemented by the WAPC, Department of Planning and the Town of Kwinana. Alcoa will only purchase land in the area around its residue operations for future residue infrastructure.</td>
</tr>
<tr>
<td></td>
<td>e) Constraints</td>
</tr>
<tr>
<td></td>
<td>Alcoa will abide by the land use decisions made by the relevant government authorities.</td>
</tr>
</tbody>
</table>

**FUTURE LAND USE**

Alcoa to investigate future land uses that could be suitable for location on closed residue storage areas and prepare a rehabilitation plan for consultation with relevant government agencies and other key stakeholders. Alcoa should ensure that this is investigated in the context of the current and planned strategic planning frameworks.

- Alcoa prepares rehabilitation and closure plans in accordance with the State Agreement Act and other government requirements.
- As residue areas are closed, potential uses for those areas will be investigated and Alcoa will consult with relevant stakeholders at that time.
- The closure strategy for the residue areas continues to be developed. This information will be included in future LTRMS reviews.

**19 REPORTING ON THE PROGRESS OF GUIDING PRINCIPLES**

Alcoa to report at least annually on its progress against the “Guiding Principles” developed by the 2011 Kwinana LTRMS SRG.

- Alcoa accepts and agrees with this principle.
# Document history and status

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Glossary

BMP  Best Management Practice
CCN  Community Consultative Network
CER  Consultative Environmental Review
CIF  Communities and Industries Forum
CPT  Cone Penetrometer
CSIRO Commonwealth Scientific and Industrial Research Organisation
CSRM  Centre for Social Responsibility in Mining
CSRSP Centre for Sustainable Resource Processing
DEC  Department of Environment and Conservation
DIA  Department of Indigenous Affairs
DoE  Department of Environment (now the Department of Environment and Conservation)
EPA  Environmental Protection Authority
EPP  Environmental Protection Policy
GHD  An engineering, architecture and environmental consulting company.
GLC  Ground Level Concentration
HDPE  High Density Polyethylene
HI  Hazard Index
HRA  Health Risk Assessment
EIP  Environmental Improvement Plan
KIC  Kwinana Industries Council
LTRMS  Long Term Residue Management Strategy
MRS  Metropolitan Region Scheme
NATA  National Association of Testing Authorities
NEPM  National Environment Protection Measures
NORM  Naturally Occurring Radioactive Material
PM2.5 Particulate Matter less than 2.5 µm in diameter
PM10 Particulate Matter less than 10 µm in diameter
PVC  Polyvinyl Chloride
RL  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.
ROWS  Run Off Water Storage
RPLG  Residue Planning Liaison Group
RSA  Residue Storage Area
SKM  Sinclair Knight Merz. A strategic consulting, engineering and project delivery company.
SRG  Stakeholder Reference Group
TEOMs  Tapered Element Oscillating Microbalances
TOR  Terms of Reference
TSP  Total Suspended Particulate
uPVC  Unplasticised Polyvinyl Chloride
URS  URS is a professional services company providing engineering and environmental expertise.
VOC  Volatile Organic Compound
WASP  Wind Assessment Siting Program
WAWA  Water Authority of Western Australia
References


Alumina Refinery Agreement Act 1961 (WA)


