Long Term Residue Management Strategy

Pinjarra 2016

Alcoa

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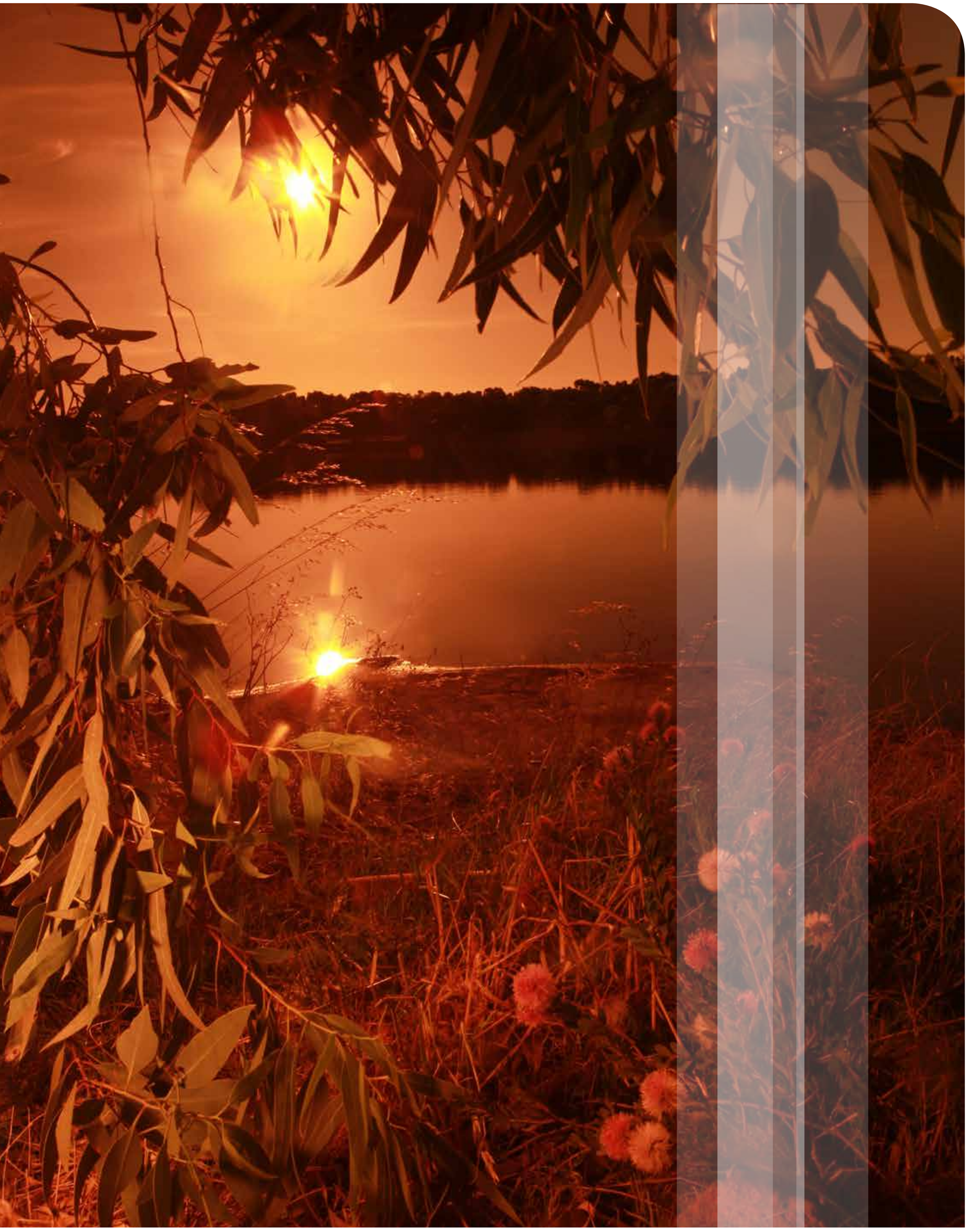
Contents



Executive Summary

Introduction

The Pinjarra Long Term Residue Management Strategy (LTRMS) was initially developed in response to a voluntary commitment to develop long term and closure management plans for residue deposits in line with Ministerial Conditions applied to the Wagerup Unit Two Expansion in 1990. In order to keep the LTRMS current it is reviewed and updated on a five yearly basis. This LTRMS represents the fourth published Strategy for Alcoa's Pinjarra Refinery.

A reference group of key stakeholders including community members, local and state government, and Alcoa representatives actively participated in the development of the Strategy over a three month period from June – August 2015.

Purpose of LTRMS

The LTRMS document is designed to inform local and state governments, as well as the wider community of Alcoa's long term management strategies and commitments for a sustainable future in residue management. In particular it outlines the current short term (5-7 years), mid-term (25 years) and life-of-mine (2045) management strategies for residue at Pinjarra Refinery, 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 document is designed to inform local and state governments, as well as the wider community of Alcoa's long term management strategies and commitments for a sustainable future in residue management.

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 is not intended to provide detailed engineering information for future residue management.

The LTRMS also addresses closure of the residue storage area, future land use options for the residue storage 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 Pinjarra 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 five to seven year period to which it relates, so that endorsement of this document by the Residue Planning and 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 approval applications required for the longer term.

The outcomes of this LTRMS will also be incorporated into the ongoing planning processes for the Pinjarra residue area.

Consultation and Key Issues

The contents of this document are based on issues and information discussed during consultation with a Stakeholder Reference Group (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 the updated LTRMS was to:

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

A summary of the SRG's deliberations was provided in the form of 30 Guiding Principles for Alcoa to consider in the development of the LTRMS. These were developed for environmental and social issues considered particularly significant by the group and include:

- efficiency of water use,
- management of current or potential surface and groundwater contamination,
- dust control,
- residue reuse options,
- residue area footprint, height and footprint reduction opportunities,
- land zoning and compatible land use planning,
- visual amenity, and
- residue closure and rehabilitation.

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 document.

Residue Footprint Options

The ultimate land area used for residue storage will be affected by:

- the volume of residue requiring storage,
- the rate at which residue is produced,
- the residue drying treatment utilised, and
- the way the residue stack is constructed.

The most significant factor affecting the final volume of residue requiring storage is the availability of alternative uses for residue.

The other significant factor affecting the size of the final footprint of the residue area is the stack design. Specifically the height to which the stack can be created, while providing the required open area for drying or storage, defines the minimum residue footprint that can be achieved.

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

- A smaller residue area footprint from which groundwater contamination could potentially occur,
- a reduction in contaminated run-off water requiring treatment and discharge after refinery closure,
- less surface area requiring rehabilitation, and
- greater separation between residue and neighbouring properties.

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

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

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

The SRG members supported this approach and design heights of between 60 metres and 80 metres above ground level for the residue areas. While doing this they also encouraged Alcoa to continue to investigate alternate technologies and processes to reduce the overall footprint.

Alcoa is currently undertaking the comprehensive residue management planning processes for the short-term (5 year), medium term (25 years), and life of the current mining lease (life-of-mine, 2045). These planning processes give consideration to the guidance provided through the LTRMS SRG process.

Constraints on Forward Planning

Despite the level of effort which goes into forward planning, significant changes 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 while 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
- the availability of key equipment and contractors.

The plans presented in this LTRMS are therefore subject to change. The five yearly review process undertaken 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:

- 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,
- rezoning, if required, of Alcoa owned agricultural land for future residue storage and drying and infrastructure requirements, and
- development and/or commercialisation of strategies to reduce residue footprint.

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 the risk of groundwater contamination. The mid-term strategy beyond the next five years includes:

- implementation or further development of residue reuse and commercialisation strategies,
- ensuring the current or expanded refinery has timely access to adequate storage capacity and open drying area,
- ensuring the current or expanded refinery can maintain an adequate water balance through access to adequate water storage facilities,
- rezoning, if required, of Alcoa owned agricultural land for future residue drying and infrastructure requirements, and
- continued investigations into post closure water management options.

Life-of-Mine Strategy

For the purposes of this planning process, the life-of-mine is considered the life of Alcoa's current bauxite mining lease, Mineral Lease 1SA (2045).

Alcoa has developed a proposed life-of-mine development envelope. This area reflects the most likely extent for development of residue storage within the current life-of-mine period. The actual extent of the area required for storage and associated infrastructure within this period will be primarily affected by the extent of developmental constraints identified within the areas to the north and east. The proposed area assumes maximum heights within the stack of between 60 metres and 80 metres above ground level.

Residue Filtration

Pinjarra Refinery is currently undertaking a feasibility assessment on new technology for residue storage (residue filtration). The filtration process produces a dry residue cake by filtering mud slurry through a membrane. Residue filtration would provide a number of potential benefits including:

- a reduction in water usage,
- a reduction in the future residue footprint,
- improved residue dam stability,
- a reduction in dust potential from residue storage areas, and
- reduction of residue storage costs.

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 residue area to allow it to be used for a range of activities for future generations.

Ongoing Stakeholder and Community Engagement and Review Schedule

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

Concluding Remarks

The development of this LTRMS has been a constructive means of engaging the community. Alcoa is very appreciative of the Pinjarra LTRMS Stakeholder Reference Group members who provided a considerable amount of personal time and commitment in working with Alcoa during 2015 to produce this important Strategy for the Pinjarra Refinery.

1 Introduction

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 9 million tonnes per annum (mtpa), equivalent to 45% of Australian production and more than 10% of world demand. The company also operates the Huntly and Willowdale bauxite mines in the Darling Range, south of Perth. A map of Alcoa's operations in Western Australia is provided in Figure 1-1.

Alcoa's Pinjarra Alumina Refinery is located 90 kilometres south of Perth and approximately 5 kilometres east-southeast of the township of Pinjarra. The refinery is situated at the foot of the Darling Scarp, in the Peel region of Western Australia, within the Shire of Murray. The land surrounding the Pinjarra Refinery and residue area is predominantly operated as a beef farming enterprise by Alcoa Farmlands.

The Pinjarra Refinery commenced operations in 1972 producing 250,000 tonnes of alumina per year. Production capacity has steadily increased to the present level of approximately 4.5 million tonnes per annum.

Bauxite is supplied to the refinery from Alcoa's Huntly Bauxite Mine, located in State forest to the east of the refinery. Alumina produced at Pinjarra Refinery is transported by rail to Alcoa's Bunbury and Kwinana shipping terminals and then exported to overseas markets or to Alcoa's aluminium smelter in Victoria. The bauxite is low grade by world standards, requiring three tonnes of bauxite to produce one tonne of alumina. As a result, large volumes of bauxite residue are generated and stored in bauxite residue storage areas (RSAs) west of the refinery.

1.2 Purpose of the Long Term Residue Management Strategy

This Long Term Residue Management Strategy (LTRMS) document is designed to inform the local and state government and the community of Pinjarra Refinery's long term residue management strategy and associated commitments. The contents of this document provide information on the issues requiring consideration in the management of bauxite residue and Alcoa's strategies in relation to future residue facilities.

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

The LTRMS is a reflection of current knowledge, technology and regulatory standards. The document is not intended to provide detailed engineering information for future residue management.

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 used to support its development.

Section 3: Overview of Pinjarra Refinery's operations and the alumina refining process.

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

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

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

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

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

Section 9: Alcoa's closure strategy and future land use options.

Section 10: Guiding Principles for residue management as developed through the Pinjarra LTRMS Stakeholder Reference Group process.

Section 11: Glossary of terms and units.

Section 12: References.

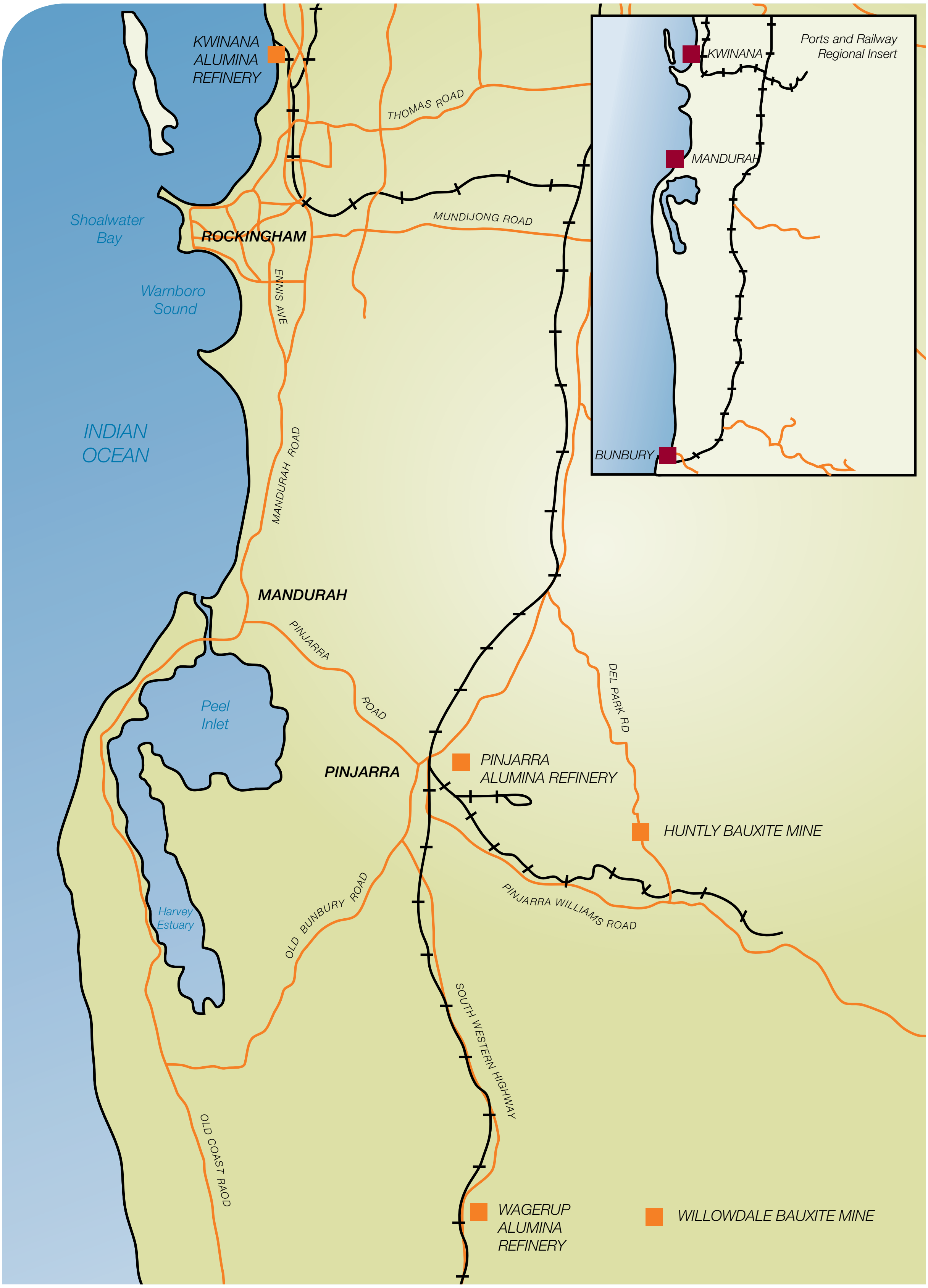


Figure 1-1: Location map.

2 Background and history of the LTRMS

Alcoa has had an active residue management program for over 50 years that has focused on emissions control, improvement in engineering management practices and alternative uses for residue.

2.1 Initial LTRMS Development
As part of the 1989 Consultative Environmental Review (CER) for the Wagerup Unit Two Expansion, Alcoa agreed to develop long term and closure management plans for residue deposits in consultation with relevant state government agencies, as well as to submit design reports and monitoring results from the 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 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 included representatives from the Department of Resources and 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 its 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. These required Alcoa to:

- develop a closure strategy and long term management plan for the RSAs 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.

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

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

2.2 2005 LTRMS Review

Alcoa initiated a review of the 1997 LTRMS in February 2004 and it was published in 2005. During this review the approach to residue management was expanded to embrace stakeholder engagement, with local community and stakeholders directly involved 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 engaging a Stakeholder Reference Group (SRG). The role of the SRG was *"To assist Alcoa in developing a long term strategy for bauxite residue management at the Pinjarra 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)."*

The main outcomes of the 2005 LTRMS review included agreement on the:

- 25 year drying area footprint,
- location of the next green field residue storage area (RSA9), and
- strategy of minimising the footprint of the residue storage area by increasing the height of the stack, as long as visual amenity and dust issues can be appropriately managed.

On the basis of this LTRMS, the 25 year footprint was subsequently rezoned to allow for residue storage and RSA9 was constructed in the agreed position on the east of the stack.

Additionally, in response to Guiding Principles developed by the SRG, Alcoa increased its focus on areas of environmental management of the residue areas, including the management and monitoring of residue dust.

2.3 2011 LTRMS Review

The 2011 LTRMS 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.

Figure 2-1: Alcoa's global sustainability model.

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.

2.4 2016 LTRMS Review

The current review of the LTRMS commenced in June 2015 and used an SRG to obtain advice and feedback on strategy options from local community representatives, local government and regulatory authorities.

The 2016 LTRMS review followed a similar format to the 2011 review, addressing residue infrastructure requirements for the life-of-mine (2045), the 25 year footprint requirements and the 5-7 year development plan; and key changes in environmental management and performance since the 2011 review.

2.5 Sustainability

Alcoa's sustainability objective is reflected in the emphasis of this document. Alcoa's approach to residue management is built on an overarching framework of sustainability and embraces stakeholder engagement, with local community and stakeholders directly involved in the planning process.

Alcoa defines sustainability as using our values to build financial success, environmental excellence, and social responsibility in partnership with all stakeholders. Our objective is to be transparent with respect to our sustainability issues and progress and to provide significant information to all of our stakeholders.

We view sustainability through three lenses:

1. Advancing our vision – we strive to achieve a net-positive result between our impacts and the sustainable value our innovation creates for customers, consumers and the world.

2. Growing our handprint – creating a more sustainable world by helping solve some of society's biggest challenges.

3. Reducing our footprint - efficient use of resources and effective control of emissions, waste and land use to drive improved environmental performance.

Alcoa integrates sustainability into its core business through targets, roadmaps, and scorecards. The comparison between our impacts (footprint) and the benefits that we provide to our customers and society (handprints) is what we refer to as our "net-positive" approach.

Alcoa was recognised in 2016 for its sustainability efforts through inclusion in the Dow Jones Sustainability North America Index for the 15th consecutive time and in the World Index.

2.6 Stakeholder Engagement

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 are employed by Alcoa to involve and inform the community of the company's activities. The following section provides an overview of the current consultative groups in place at Pinjarra and details of the process used to establish the Pinjarra LTRMS Stakeholder Reference Group.

2.6.1 Community Consultative Network

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

CCN membership is drawn from neighbours, community leaders, environmental groups and local government representatives within the region. The CCN meets with Pinjarra Refinery management and representatives on a bi-monthly basis with an expectation that information obtained through the CCN is then shared with their wider community networks. Meeting reports are published in the local newspaper.

2.6.2 Environmental Improvement Plan (EIP) Consultation Process

EIPs represent Alcoa's public commitment to continuously improve environmental performance, reduce environmental impacts and develop more sustainable operating practices. EIPs in WA are a voluntary initiative by Alcoa which, in many cases, go beyond the environmental management requirements specified in Alcoa's formal licence conditions.

Pinjarra Refinery's EIPs are developed by a working group made up of representatives from the local community, local and state government and Alcoa. The aim of the working 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 greenhouse gas and energy efficiency,
- noise and waste management,
- water conservation,
- groundwater management,
- land management, including visual amenity, rehabilitation and fauna/ flora management,
- community involvement, and
- environmental regulation.

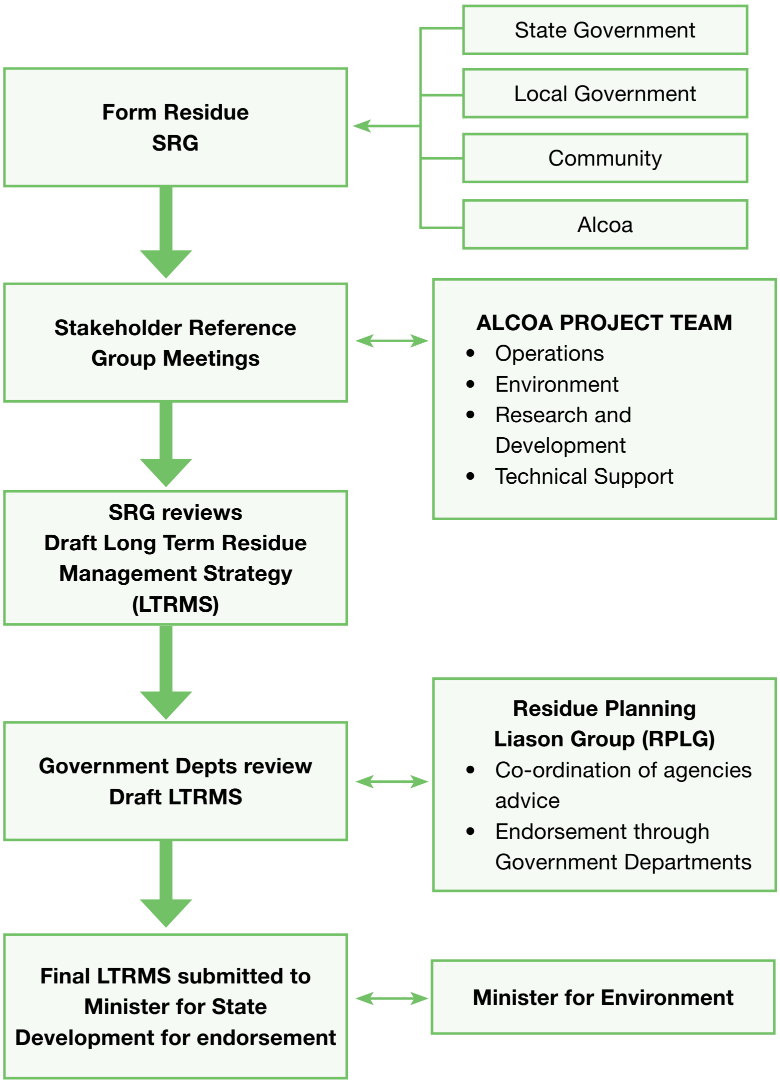


Figure 2-2: Framework for SRG participation in LTRMS development.

2.7 Pinjarra LTRMS Stakeholder Consultation Process

The development of this LTRMS was informed by feedback from the LTRMS stakeholder consultation process.

This process involves formation of an advisory group, with stakeholder groups represented, to work with the company in their development of the LTRMS. 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 Pinjarra LTRMS SRG is given an opportunity to review the draft LTRMS before it is presented to the Residue Planning Liaison Group (RPLG) for its comments. Once Alcoa has responded to the RPLG comments on the LTRMS, Alcoa submits it to the Minister for State Development. Input is then sought from the Minister for Environment before the Minister for State Development endorses the Strategy.

The LTRMS is intended 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 anticipated longer term residue infrastructure.

The stakeholder consultation framework for the Pinjarra Refinery LTRMS review is presented schematically in Figure 2-2 and proceeded as follows:

2.7.1 Formation of the Pinjarra LTRMS Stakeholder Reference Group

The Pinjarra LTRMS SRG was formed in June 2015 and met regularly over a three month period.

Affiliation	Name
Community	
Greening Australia (Non Profit Organisation - Environment)	Bayden Smith
Community Member	Stewart Evans
Community Member	Alan Edgar
Local Government	
Shire of Murray – Executive Manager Strategic Development	Leanne McGuirk
State Government	
Department of Environment Regulation	Chris Malley
Department of State Development	Phil Knight
Employee	
Pinjarra Residue Employee	Peter Hornburg
Alcoa	
WA Operations Residue Manger	David Honey
Senior Environmental Scientist, WA Operations – Residue	Kathryn Forrest
Residue Operations and Maintenance Manager	Matthew Cox
Pinjarra Refinery Environmental Manager	Anne Price
Community Relations Officer	Fiona Bell

Table 2-1: Pinjarra LTRMS SRG membership.

2.7.1.1 Community Membership

Advertisements inviting community participation were placed in three local newspapers: the Murray Mail, Mandurah Coastal Times and Pinjarra Murray Times.

Current members of the CCN were also invited to participate in the LTRMS consultation process. Three of the members of the Pinjarra Refinery SRG were community members.

2.7.1.2 Government Representation

Government representation was sought from a range of agencies and received from the Shire of Murray, the Department of Environment Regulation and the Department of State Development.

2.7.1.3 Alcoa Representation

Alcoa was represented on the LTRMS SRG by its WA Operations Residue Manager, David Honey, the WA Residue Operations and Maintenance Manager, Matthew Cox, Pinjarra Refinery Environmental Manager, Anne Price, WA Operations Residue Senior Environmental Scientist, Kathryn Forrest, Pinjarra Residue Employee, Peter Hornburg and Community Relations Officer, Fiona Bell.

Meeting reports were produced by Kathryn Forrest and Fiona Bell.

2.7.2 Stakeholder Reference Group Terms of Reference and Operating Procedures

Independent facilitator, Andrew Huffer, was appointed to the Stakeholder Reference Group. The initial meeting of the SRG involved the clarification of the group's role in the LTRMS planning process. It was agreed that the responsibilities of the SRG were 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 and impacts on neighbouring land,
- provide advice to Alcoa on factors that influence long term residue management,
- provide a summary of their deliberations to be included in the development of the LTRMS, and
- conform to the Terms of Reference (TOR) agreed to by the SRG.

It was agreed to hold meetings every week until all issues were resolved.

A list of agenda items and a proposed meeting schedule was developed for the SRG. Issues dealt with at SRG meetings were tabled in meeting reports. Eight meetings were held in Pinjarra to address the issues raised by the SRG.

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

2.7.3 Key Outcomes of the Stakeholder Reference Group Process

As a result of the process undertaken, 30 Guiding Principles were developed by the SRG over 16 topics. These Guiding Principles have been considered by Alcoa and addressed, where possible, in the Pinjarra LTRMS. The complete table of Guiding Principles, together with Alcoa's responses, is provided in Section 10. Guiding Principles on individual topics are also referenced throughout the body of the report, as appropriate.

As a result of the process undertaken thirty (30) Guiding Principles have been developed by the SRG over sixteen (16) topics. These Guiding Principles have been considered by Alcoa and addressed, where possible, in the Pinjarra LTRMS. The complete table of Guiding Principles, together with Alcoa's responses, is provided in Section 10.

Meeting No.	Date	Topics Covered
1	9 June 2015	Welcome and team formation Long term residue management strategy overview Residue management overview
2	16 June 2015	Pinjarra residue storage area tour
3	23 June 2015	Residue development strategies and future options
4	30 June 2015	Environmental management and performance, including: Dust, odour, water use, surface and groundwater, waste, oxalate and residue reuse
5	7 July 2015	Environmental management and performance, including: Rehabilitation research, visual amenity, closure planning and final land use options
6	14 July 2015	Guiding Principle development
7	21 July 2015	Guiding Principle development
8	4 August 2015	Alcoa's response to Guiding Principles

Table 2-2: LTRMS SRG meeting schedule.

2.7.4 Consultation Guiding Principles and Alcoa's Commitments

In response to the information provided, the Pinjarra LTRMS SRG developed one Guiding Principle relating specifically to stakeholder engagement. This is presented below, together with Alcoa's response.

Guiding Principle: 16) Reporting of the Progress of Guiding Principles

Alcoa to report annually to the CCN on its progress against the "Guiding Principles" developed by the 2015 Pinjarra LTRMS SRG.

Alcoa's Response

Alcoa accepts and agrees with this principle.

3 Alumina Refining Process

3.1 Overview
The Pinjarra 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 left over after alumina is extracted) in impoundment areas known as the RSAs.

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 then pumped out 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 are added causing alumina hydrate to crystallise. The liquor and hydrate are separated. The hydrate crystals are sized, and crystals of a suitable size are 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 onsite power station and a cogeneration facility. The primary fuel supply for the power station boilers is natural gas.

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 in RSAs adjacent to the refinery.

The residue consists of a coarse sand fraction (often termed "red sand") and a fine silt fraction (often termed "red mud"). 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 50% of the residue stream is sand and 50% 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.

Included within the residue complex are a number of other facilities that support the refining operations. These include ponds designed to cool the plant process waters (cooling ponds) and to store rainfall run-off water from the refinery site and residue area (run-off water storage (ROWS) ponds). The ROWS pond is designed to contain the accumulated run-off from a 1:100 wet year so that no contaminated water is released to the environment. Water is recycled back to the refinery via the cooling pond.

3.8 Refinery Water Circuit

Pinjarra Refinery currently uses approximately 3.1 kilolitres (kL) of water per tonne of alumina product (annualised figure). The refinery has been designed to operate an efficient 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, water bound within the residue mud and sand, and some seepage from the residue area. Some areas of elevated alkalinity have been identified beneath the residue area which suggest some losses occur from historical residue areas (see Section 7.9 for further details). Make-up water is taken from licensed surface and groundwater sources, including recovery bores within the refinery in areas identified to have elevated alkalinity, and the Pinjarra townsite waste water treatment plant. During years of low rainfall, make-up water may be sourced from the Water Corporation. Onsite sources of make-up water include water contained in the caustic soda, rainfall runoff and the refinery sewerage system. All rainfall runoff from the refinery site and RSAs is captured, stored in lined ponds and recycled back into the refinery process.

Residue area water management is discussed in more detail in Section 7-8.

4 Bauxite Residue Management

4.1 Overview

In 1987, Pinjarra Refinery adopted an alternative storage technology termed 'dry stacking'. This process involves pre-thickening the residue and then depositing it in layers which are dried through solar evaporation. The process is assisted by physically turning over the mud and produces a high-density, stable stack of residue upon which the next mud layer can be placed.

Dry stacking of residue is fully operational at all three of Alcoa's Western Australian refineries and this type of storage is now being adopted by other minerals industries as a best practice. The advantages of this method include:

- a significantly reduced footprint,
- reduced environmental risks, such as groundwater impact, and
- a more stable landform that enables direct rehabilitation and a wider range of potential future land uses.

In 1985, Alcoa compiled a detailed report of the proposed residue drying operation for the Pinjarra Refinery. This report formed the basis for government approval of the changes to residue management.

Operating experience gained at Pinjarra, Kwinana and Wagerup and continual improvements to the methods of RSA construction, have provided a sound basis on which the original residue management strategies can be updated. Alcoa is now able to project, with confidence, the facilities required to sustain the dry stacking operation well into the future.

Alcoa commenced commissioning of its first residue filtration facility at Kwinana Refinery in the first half of 2016. The filtration facility utilises large scale filter to force the moisture out of the residue, leaving behind a dry filter cake. This filtration process dramatically reduces the required drying time of the residue from approximately 100 days to 30 minutes. Residue filtration is expected to provide many potential benefits for residue management including:

- a reduction in water usage,
- a reduction in the future residue footprint,
- improved residue dam stability,
- a reduction in dust potential from residue storage areas, and
- reduction of residue storage costs.

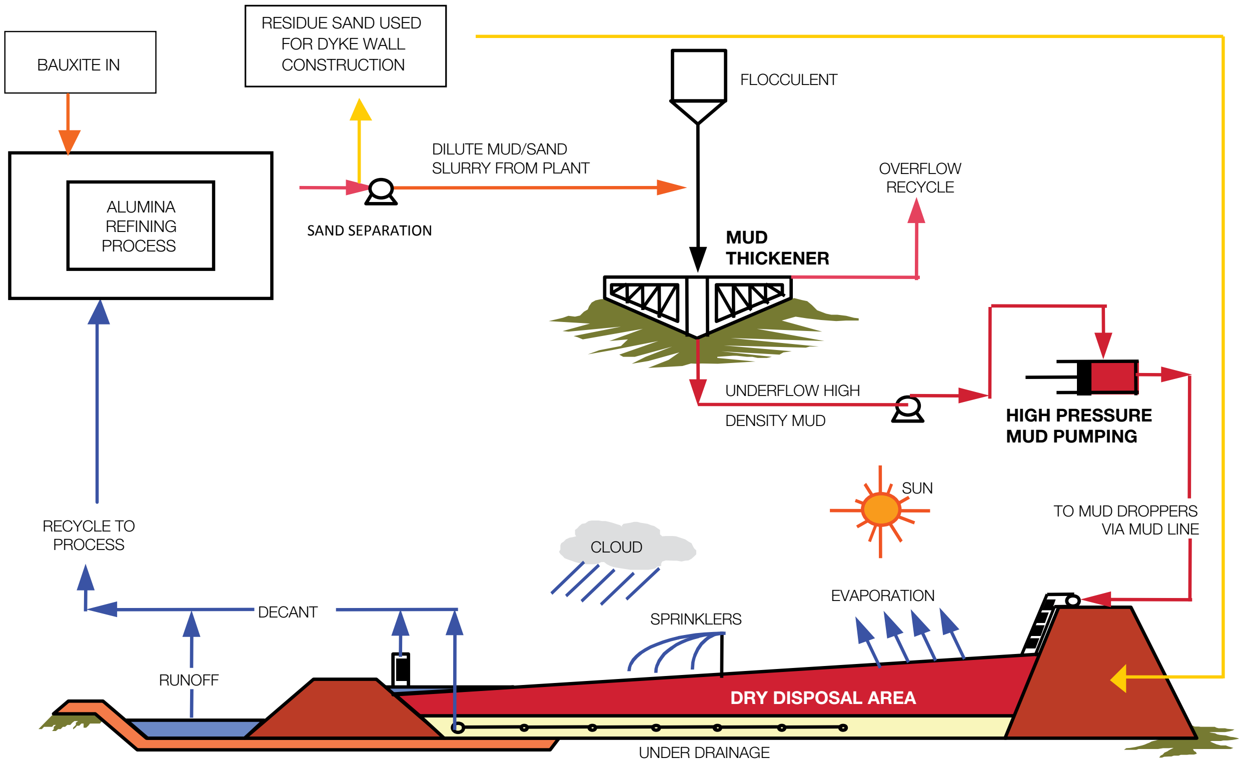


Figure 4-1: Coarse particles are separated from fine tailings using cyclones and counter-current wash towers.

Alcoa is currently looking at also introducing residue filtration at Pinjarra Refinery. More information about this can be found in Chapter 8.

Alcoa believes the bauxite reserve 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 volumes 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 2015, the total residue storage footprint at Pinjarra, including water storage facilities, was 780 hectares and the maximum residue height was 50 metres above natural ground level (RL 70). The residue footprint expansion is planned to the east in the next five to seven years, and to the north and east of the current footprint within the next 35 years. The rate of expansion of the residue area footprint will depend on the actual production rates over time and the height of the stack. The height of the RSAs will also influence the direction and timing of the footprint expansion; a higher stack height allows the footprint to be contained to a smaller overall footprint.

4.2 Residue Characteristics

4.2.1 Chemical Condition

As described in Section 3, 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 that 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.

4.2.2 Physical Conditions

Bauxite residue is composed primarily of iron and silica minerals. Residue from Darling Range bauxite is characterised by a high coarse fraction, due to silica in the bauxite. The coarse fraction can be considered as a fine to medium grained sand with a specific gravity of 2.9. This residue sand has proved to be an ideal material for embankment and road construction within the dry stacking operation, as a free draining material

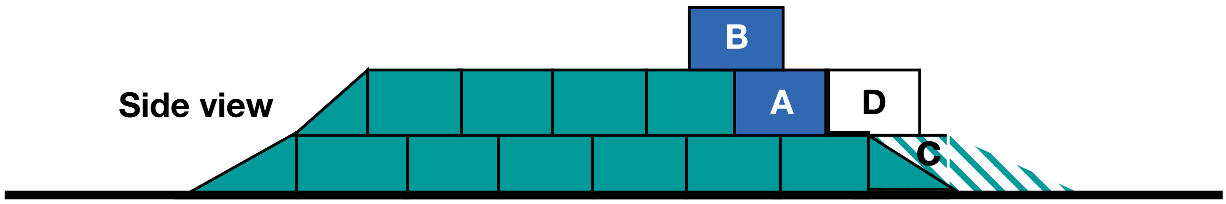


Figure 4-2: Schematic diagram of the dry stacking process.

suitable for surface rehabilitation, and for the construction of drainage layers at the base of the RSAs (Alcoa, 1997).

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

4.3 Physical Structure of Storage Areas

A schematic diagram of the dry stacking process used at Alcoa's Residue Storage Area is presented in Figure 4-1.

The fine tailings are pumped to a thickener vessel where they are settled using flocculent, producing a higher-density underflow slurry of around 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 solar evaporation.

To assist the natural drying process, the surface of the RSAs is mechanically turned over using bulldozers and amphirols. The final dry density of the tailings is around 70% solid material. This compares to the final density of 60 - 65% solids typically achieved using earlier wet disposal methods.

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

4.3.1 Environmental Concerns

The main concern relating to the physical condition of the residue is the potential for embankment failure, which could result in the release of residue slurry or liquor into the surrounding environment. Also of possible concern are the more gradual processes of wind and water erosion, particularly on the sloped embankments of the residue deposits.

4.3.2 Current Management Strategies

From the commencement of Alcoa's operations in Western Australia, RSAs have been designed and constructed in accordance with accepted engineering standards. Prior to the introduction of dry stacking, residue embankments were designed as water retaining structures in recognition of the need to contain the residue leachate, which added conservatism to their design.

The introduction of dry stacking of the residue has reduced the likelihood of the release of residue slurry or liquor to the surrounding environment, as the red mud is contained initially by residue sand embankments and then dried to achieve a minimum strength which ensures the deposit is stable. The lack of any significant volume of free water either within or on the surface of the deposit, further decreases the risk of slope failure.

The overall stability of the residue storage area stacks has been designed in accordance with international standards to accommodate both static and earthquake loadings. The analysis has been taken further to demonstrate the mode of failure should it occur under extreme conditions. A finite element analysis showed the failure to be limited to small horizontal and vertical displacements, rather than a circular slip failure of the outer stack slope. While such a failure might cause short term operational problems (such as ruptured pipelines) it should not result in any flow of residue into the surrounding environment.

All major embankments are monitored regularly to check on their structural condition and visual inspections are carried out routinely. In addition, the structural integrity of water storage ponds and RSA embankments are inspected annually by a third party consultant.

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.

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

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 RSAs 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 RSAs.

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

4.5 Construction of New Residue Facilities

Prior to the design of a new residue facility, the area concerned is subject to a detailed site investigation that includes an evaluation of geotechnical and 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.

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

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

- a constructed low permeability base and embankment seal that is at equivalent to approximately 0.45 metres depth of mechanically compacted clay with a hydraulic conductivity of less than 10^{-9} m/s, with a synthetic geomembrane (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 system is designed to cater for run-off generated from the residue system as a whole during both a 1:100 wet year, and a 1:100 year storm event),

- 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.

Subsequent lifting of embankment walls is completed using an upstream embankment methodology and is subject to rigorous design criteria. 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 carried out using a cone penetrometer (CPT) which gives a profile of material strength by measuring the resistance generated by forcing a probe through the residue stack. The results are then used as input into a stability software program which calculates 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.

4.6 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 become a resource rather than a waste. The company also recognises that if significant reuse can be achieved, the rate of expansion of the RSAs can be slowed, and the long term impacts of residue storage can be reduced.

4.6.2 Reuse Strategies

Bauxite residue is comprised of two main fractions that are treated to produce two distinct products. The coarse fraction (>150 µm) can be treated to produce a material known as Red Sand™ and the fine component (<150 µm) into a material known as Red Mud™ or Alkaloam®.

A number of opportunities for residue re-use continue to be investigated as part of Alcoa's research and development program based at Kwinana. Alcoa's primary focus is currently on commercialisation of Red Sand™.

Alkaloam®

Further opportunities for re-use of Alkaloam® have been put on hold until Red Sand™ has been formally approved by the Department of Environment Regulation (DER) for re-use following assessment under the Waste Derived Materials framework. In the interim, an extensive leaching assessment on Alkaloam® is underway at the Chemistry Centre of Western Australia as a pre-requisite for submitting an application to the DER to have the material assessed as a Waste Derived Material for re-use.

Reuse of Red Sand™

Alcoa's residue sand is currently used for the construction of RSAs, 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 and construction material. The resulting product is known as Red Sand™.

It is proposed that Red Sand™ be used in a number of applications which has been trialled and proven to perform equal to or better than virgin sand materials. These include top dressing of turf for recreational uses, road construction, and industrial land development. Red Sand™ is well structured and has improved phosphate retention properties compared to local sands. Red Sand™ has also been assessed as a growth medium for turf production, as a top dressing soil for golf courses, as a bunker sand for golf courses, for concrete production and as a general fill material for land reclamation.

The technology to produce Red Sand™ has been demonstrated through a pilot plant operated at Alcoa's Wagerup Refinery with the sand produced from this plant used by the Department of Main Roads in a road construction trial on Greenlands Road (Pinjarra, Western Australia), and by Fairbridge Village (Pinjarra, Western Australia) to top-dress its main oval. The pilot plant has also been operated at Alcoa's Kwinana Refinery with the sand produced being used to top-dress the Alcoa Social Club oval, a series of trials with various golf clubs, and an industrial land development trial in conjunction with Landcorp.

Various health and risk assessments have been conducted on Red Sand™ to ensure its safe utilisation. These include:

1. A radiological assessment which has resulted in approval by the Radiological Council of Australia for road construction and top dressing.

2. A health risk assessment which has been reviewed by the Department of Health, resulting in their endorsement of Red Sand™ for top dressing, road construction, and industrial land development.

3. An independent technical assessment, conducted by the Energy Research Centre of the Netherlands (ECN), has been undertaken to assess Red Sand™ against the Dutch Building Material Decree, a well-established set of criteria that are well referenced and used widely. The review did not identify any issues with the use of Red Sand™ in construction works within their framework.

4. An independent peer review of the Red Sand™ project has been conducted by KMH Environmental. The peer review process was commissioned to identify any potential risk associated with use of Red Sand™, review these risks against the technical assessments and specialist investigations already conducted on Red Sand™, and identify any technical gaps and recommendations for further work. The review concluded that Alcoa has taken an expansive approach to evaluating and assessing the Red Sand™ material. No significant gaps were identified in the review.

One of the major hurdles for the use and commercialisation of Red Sand™ has been the lack of a clear regulatory approval process within Western Australia. In December 2014, the Department of Environment Regulation (DER) released guidelines for the use of waste derived materials (WDM). These guidelines provide a pathway for the removal of the waste classification of WDM's to facilitate their reuse. Alcoa has conducted the necessary risk assessment required as part of the guidelines resulting in the development a set of material specifications based on soil and water quality limits endorsed by the DER. Alcoa submitted an application for the reuse of Red Sand™ to the DER in June 2016 and is awaiting a response.

Alcoa has also led the implementation of leaching test methods developed in the European Union by the ECN into Western Australia, which has now been endorsed by the DER and referenced in their WDM guidelines as a part of their risk assessment process. Under a joint project with the Minerals Research Institute of Western Australia (MRIWA), the Chemistry Centre of WA and other industry sponsors, these leaching methods are currently being developed, applied and validated in WA.

4.6.3 Residue Reuse Guiding Principles and Alcoa's Commitments

In response to the information provided, the Pinjarra LTRMS SRG developed two Guiding Principles related to alternate uses for residue. These are presented below, together with Alcoa's response.

Guiding Principle: 2a) Residue Reuse - Priority

The SRG encourages Alcoa to continue with its efforts to have government develop a simplified approvals process and legislative framework that will enable residue re-use products to go to market on a commercial basis.

Alcoa's Response

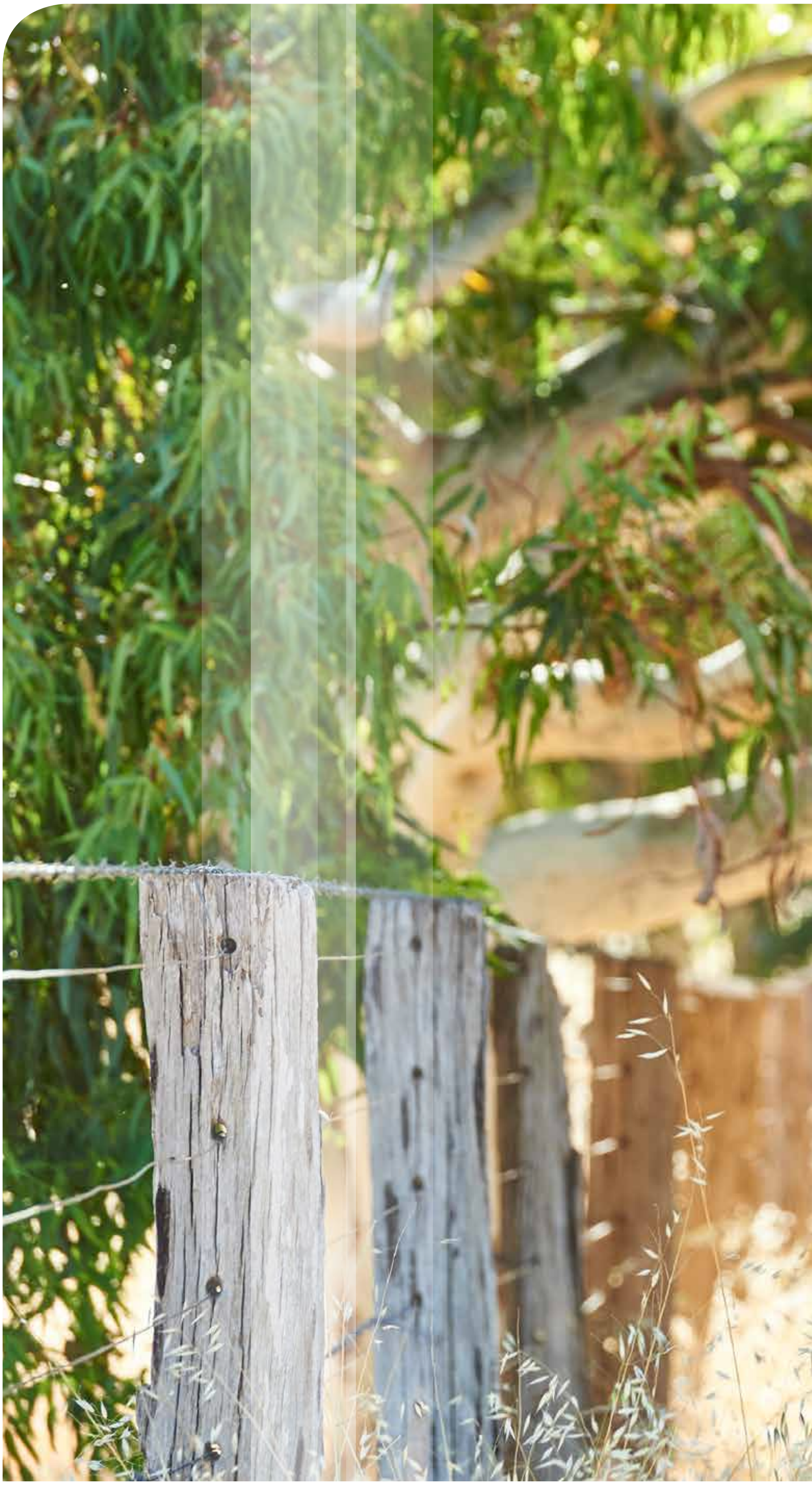
Alcoa accepts and agrees with this principle. Our initial focus is on gaining approval for reuse of the sand fraction of the residue. Once sand is being successfully marketed, we will focus on gaining approval for reuse of the mud fraction of the residue.

Guiding Principle: 2b) Residue Reuse - Reporting

Alcoa to report to the CCN 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.



5 Economic and Social Setting

5.1 Description of the Local Community

The Pinjarra Refinery is located approximately 5 kilometres east-southeast of the township of Pinjarra, within the Shire of Murray and the broader Peel Region. Pinjarra is located on the banks of the Murray River and situated on the South Western Highway approximately 86 kilometres south of Perth and 20 kilometres from the coastal centres of Mandurah and Rockingham. Despite proximity to these urban centres, the Shire of Murray is predominantly semi-rural. The smaller town of North Pinjarra is located approximately 2.5 kilometres northeast of Pinjarra.

Peel is the fastest growing region in Western Australia, the estimated resident population of the Peel Region was 124,500 in 2013, accounting for five per cent of Western's Australia's population.

During the period 2003 – 2013, the highest population growth area in the Peel Region was the Serpentine-Jarrahdale Shire (5.7%), followed by the Shire of Murray (3.5%) and the City of Mandurah (4.5%). The Shire of Murray currently makes up 13% of the Peel region's population.

Alcoa plays a critical role in sustaining the Peel Region's workforce as a major employer in the region and a contributor to the Peel Region's Gross Regional Product. An overview of Alcoa's economic and social contribution to Australia and the Peel Region is provided in Section 5.3.

5.1.1 Aboriginal Community

The Aboriginal people of the South West region are a rich component of the society in and around Pinjarra. In 2011, the Australian Bureau of Statistics census reported approximately 2600 aboriginal Australians lived in the Peel region.

In 2000, Alcoa commissioned a report describing the Aboriginal people of Pinjarra. The report took 12 months to produce and is now held in the Battye Library. This comprehensive work describes the history of the region and the genealogies of nine of the most prominent Aboriginal families and elders of today.

This work was conducted in parallel with an archaeological and ethnographical review of the land surrounding the refinery and residue area. Results of heritage site surveys are discussed in Section 6.6.1.

In 2004, Alcoa commissioned an Ethnographic Report on an Aboriginal Community Consultation Project (de Gand, 2004) to ensure that appropriate elders of the Aboriginal community in Pinjarra were consulted regarding potential impacts associated with the Pinjarra operations. The process concluded that Alcoa is communicating with the appropriate elders and confirmed the processes of consultation into the future. The following comments have been extracted from the report and provide an insight into the Aboriginal communities in the Pinjarra region.

Hallam (1975) states that in pre-settlement times, Aborigines maintained the Swan Coastal Plain as open forest and grassland through repeated and deliberate burning. The forest habitat provided for a variety of mammals, and the grassland provided for pastures for kangaroos as well as facilitating the movement of people.

Because of the abundance of food resources on the Pinjarra Plain and the absolute dependence of Aboriginal people upon the land and its resources, a substantial Aboriginal population was maintained in the region.

Bindjareb Nyungar people (Berndt, 1980) historically populated the region of the Swan Coastal Plain, on which the Pinjarra Refinery is located. Family groups who belonged to the Bindjareb Nyungar were further defined by the location of their home territory. For example, the Darbalung were the people that occupied the estuary (Mandurah), Buyun-gur were the people that occupied the hills and the 'river people' were called Bilgur (beel or bil meaning 'river') (Bates, 1985).

As the Swan Coastal Plain was so abundant in food resources, the Nyungar people came to the area on a yearly basis in February, from the surrounding regions such as Brookton, Pingelly, Bunbury, Collie and Perth, to harvest, fish and attend meetings (Contos, 1998). This information was confirmed by Joe Walley who stated that "People came through Oakley Brook from Brookton, Beverley and Pingelly on their way west to Mandurah" (Joe Walley, pers. comm.). Places where other such meetings were held were Burugup, Mandurah and Pinjarra.

Different Aboriginal groups in the South West Region had their own myths and Dreaming stories, which were specific to the tracts of land that they inhabited. However, members of adjoining groups intermarried, traded, passed on information, held joint religious ceremonies and had other festivities (Berndt, 1979; de Gand, 1999).

Aboriginal people believed that the actions of Ancestral Beings created all life forms as known today including tribal territories and languages. All living things therefore shared a life force that stemmed from the Dreaming. Individual Aboriginal people were close to particular animals or plants because they shared this life force and regarded these animals or plants as soul brothers or sisters. Affinities with the plant or animal world were expressed in daily life as well as ritually. For example, an individual would not eat the plant or the flesh of the animal they shared this form of kinship with. However, on ritual occasions they would consume their totem in order to demonstrate affinity with it.

Other specific affinities to the Nyungar individual could be specific localities in the person's tribal territory where significant events had taken place, and/or totems that were associated with religious categories and were part of the progression in the religious knowledge that correlated with progressive initiations.

This rich culture and background provides the foundation for the Aboriginal people in Pinjarra today.

5.2 Overview of Alcoa's Economic and Social Contribution

5.2.1 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.

The Pinjarra Refinery is a major regional employer with approximately 1000 employees. Alcoa encourages local suppliers to conduct business with the company and the refinery. It invites local business to bid on locally supplied or manufactured goods or services and gives preference to local business in a competitive situation. Alcoa also works with local business groups to identify and utilise local suppliers and where possible, structures bids to enable local supplier participation.

5.2.2 Meeting Global Demand

During the past 50 years Alcoa has grown into one of Australia's major mineral exporters. Alcoa of Australia Limited operates the largest integrated bauxite, alumina refining and aluminium smelting system in the world.

The Pinjarra Refinery is currently one of the world's most efficient alumina refineries. In order to maintain its global competitiveness, Alcoa is pursuing ways to further improve efficiencies and increase production to meet global demand at its existing operations, as well as investigating potential new projects.

5.3 Social Contribution

The Pinjarra Refinery provides partnerships and sponsorships to community organisations in a range of fields and capacities. Recent partnerships in the region have assisted with improvements to the Community Centre, the Murray Regional Equestrian Centre, Murray Leisure Centre Clubrooms, Cantwell Park and Kingfisher Park.

During the past 50 years Alcoa has grown into one of Australia's major mineral/energy exporters. Alcoa of Australia Limited operates the largest integrated bauxite, alumina refining and aluminium smelting system in the world.

6 Environmental, Heritage and Planning Setting

Understanding the environmental, heritage and planning setting of the Pinjarra residue area provides a context for the environmental aspects associated with the operations. The following section provides an overview of the physical and cultural setting of Alcoa's Pinjarra Refinery operations.

6.1 Climate

Pinjarra has a Mediterranean type climate characterised by warm, dry summers and mild, wet winters. Detailed climatic data is available from the Bureau of Meteorology monitoring location in Pinjarra town and Alcoa's weather station.

6.1.1 Temperature and Humidity

Pinjarra temperatures are characteristic of the South West region of Western Australia and are similar to those recorded in Perth. The warmest months at Pinjarra 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 maximum temperature is around 17 degrees.

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

6.1.2 Rainfall

Pinjarra has been experiencing a significant decreasing annual rainfall trend since the late 1960s and this decrease has further accelerated since 1993. Average annual rainfall over the last decade (2006 to 2015) was 706 mm. Approximately 80% of the total annual rainfall is recorded between April and September. The average annual rainfall recorded at the Pinjarra Post Office has decreased markedly since the 1970s. This trend is consistent across the south-west of Western Australia. The change to a lower rainfall regime in the late-1960s shows a reduction of 166 mm from 996 mm in the period 1917 to 1968 to 830 mm in the period 1969 to 2014.

6.1.3 Wind

Winds at Pinjarra are controlled by synoptic weather patterns, local features such as the topography, and sea and land breezes. Pinjarra Refinery is located at the base of the Darling Scarp. This topographic feature:

- generates very strong easterly "foothill" winds (up to a factor of two or more times higher than elsewhere on the coastal plain) that are typically experienced during the summer months from early evening to several hours after sunrise,
- creates rotars or reversals near the foothills during easterly winds,
- channel or deflect westerly winds up the escarpment, and
- create katabatic flows down the escarpment.

The most pronounced of these localised effects is the generation of very strong easterly winds, up to a factor of two times higher than elsewhere on the Coastal Plain. These winds can extend up to eight kilometres west of the escarpment but are usually more localised.

In summer, the predominant winds are moderate to strong east-southeasterly winds and moderate southwesterly winds. The strong southeasterlies are the result of the frequent synoptic easterlies at this time of the year and the development of accelerated flows down the escarpment. The southwesterly winds are associated with development of the sea breeze. For the winter months, the winds are predominantly north-northeasterly, due to prevailing synoptic patterns and katabatic winds.

6.2 Geology, Soils and Topography

The geology of an area has a large effect on the shape of the land and the type of soil that is formed. The land surrounding the Pinjarra Refinery lies at elevations between 25 metres and 50 metres above mean sea level (AMSL). The land slopes gently to the west and rises to 75 metres AMSL in the foothills of the Darling Range, and up to 200-300 metres AMSL on top of the scarp, east of the refinery. Figure 6 -1 illustrates the geology of the area.

The Pinjarra Refinery and residue area are located next to a boundary between two geological regions: the Swan Coastal Plain and the Yilgarn Craton. The Swan Coastal Plain is generally flat with gentle undulations and predominantly comprises sedimentary material which, geologically speaking, is quite young. East of the Alcoa site, the Darling Escarpment rises abruptly to a height of around 300 metres. This area is known as the Yilgarn Craton. The Yilgarn Craton is characterised by outcropping granites and deep lateritic soils, which are some of the oldest in the world.

The refinery and residue areas are underlain by geological formations that are not laterally continuous. The upper section of the Leederville Formation is composed of silts, clays, siltstones and silty or clayey sands.

The Leederville Formation is found at a depth of approximately 20-30 metres and extends to about 120 metres beneath the residue facilities. The Cattamarra Coal Measures then extend to a greater depth and are characterised by sandstone, siltstone, shale and some minor coal. This underlying geology is covered by a relatively shallow superficial formation comprising clay, clayey sand and sand (with the Guildford Clay and the Yoganup Formation being the most dominant) up to 20 metres thick.

The topography and underlying geology on the site influence the patterns of development, with the most heavily developed areas being flat, cleared regions of the Coastal Plain. Undeveloped areas lie in inaccessible parts of the escarpment or poorly drained locations.

It is also important to note that the South West region of Western Australia is of particular interest to seismologists as there is an apparent concentration of earthquakes in the area. This area, roughly between Geraldton and Albany, is known as the South West Seismic Zone. The zone exists on the Yilgarn Craton and runs in a northwest-southeast direction inland from the Darling Escarpment (although the exact boundaries of the zone are still imprecise) (Seismicity WA, 2004). In accordance with the West Australian Department of Mines and Petroleum Tailings Storage facilities code of practice, design criteria for RSAs account for earthquake risk and long term stability.

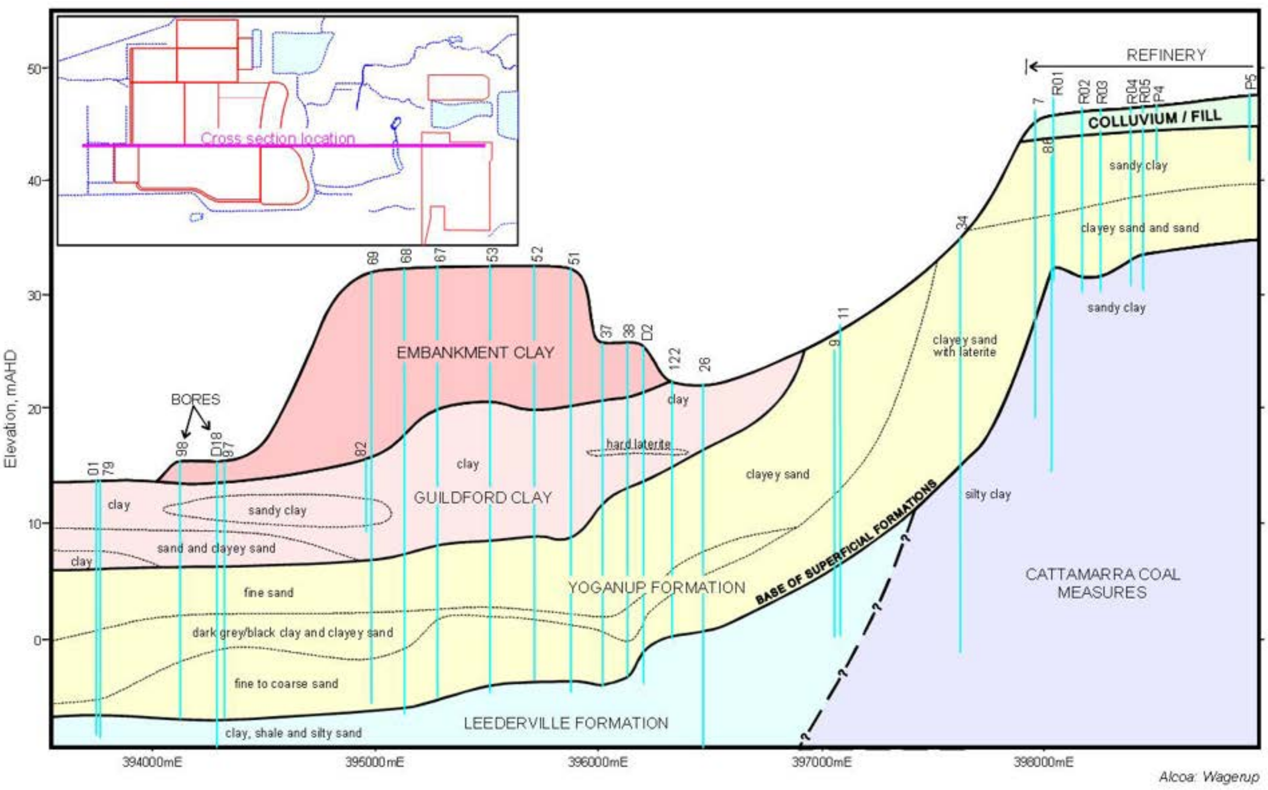


Figure 6-1: Perspective view showing schematic geological section.

6.3 Hydrology

6.3.1 Groundwater

The Pinjarra site lies at the eastern edge of the Perth Basin, the major groundwater feature of the Swan Coastal Plain. The Perth Basin extends from north of Geraldton to the lower southwest of Western Australia. The Perth Basin comprises several aquifers, many of which are important sources of groundwater. Shallow aquifers include the superficial formations (lying near the surface of the soil) and the Leederville Formation, which is found at a depth of approximately 20-30 metres, and reaches a thickness of up to 650 metres. A major aquifer, known as the Yaragadee Formation, underlies the majority of the Perth Basin. The Yaragadee aquifer is extremely deep (up to 3000 metres) and old (with groundwater of tens to hundreds of thousands of years age).

Near the residue areas, the Guildford Clays dominate the shallow soil type. The low permeability clays form an important barrier to vertical and horizontal groundwater flow. Pathways for local groundwater movement are nonetheless provided by the presence of sandy zones, dissected clays and lateritic intrusions. The Guildford Clays are underlain by sands and clayey sands in the Yoganup Formation.

Beneath the Yoganup Formation lies the Leederville Formation. The upper section of the Leederville Formation comprises gravelly silts, clays, siltstones and silty or clayey sands. A layer of dark silty clay or shale often identifies the top of the Leederville Formation, and forms an effective hydraulic barrier. In some locations, however, this layer is not present and the Yoganup and upper Leederville Formations are hydraulically continuous (PPK, 2002).

The major aquifer underlying the Leederville Formation is the Yarragadee, which is replaced in the Pinjarra region by the Cattamarra Coal Measures. The Cattamarra Coal Measures are part of the Cockleshell Gully Formation, which extends from Rockingham in the north to Kemerton in the south.

The superficial aquifer has limited groundwater supply potential. Recharge is predominantly by infiltration of rainfall and groundwater discharges as base-flow to the surface drainage. Near the residue area, the top part of the superficial formation is dominated by the Guildford Clay formation. The low permeability clays of this formation form an important barrier to vertical and horizontal groundwater flow.

There is little evidence of discernible alteration of groundwater conditions beyond the boundaries of the residue area due to contaminant migration. There is some evidence of localised alteration of groundwater conditions in the shallow Leederville Formation directly under the residue area.

6.3.2 Surface Hydrology

Regional surface hydrology is strongly determined by the underlying geology and regional topography. The Murray River is the major drainage pathway for the region, and is fed by sub-catchments draining the foothills. The Murray River ultimately drains into the Peel-Harvey Estuary. Surface flows ultimately discharge into the Murray River.

The two creek lines directly associated with the refinery and residue area are Oakley Brook to the south and Barritt Brook to the north. During construction of the refinery and residue area, surface water dams were created for both brooks with the water being used for refinery purposes. Alcoa has two structures at Oakley Brook; the Oakley Brook Detention Dam and the Lower Oakley Pumpback Dam, which are designed to hold surge following rainfall events. Overflow from these dams continues on its original course. The overflow from Barritt Brook was redirected around the northern boundary of the residue area and in 1996 redirected into an Alcoa created clay borrow pit.

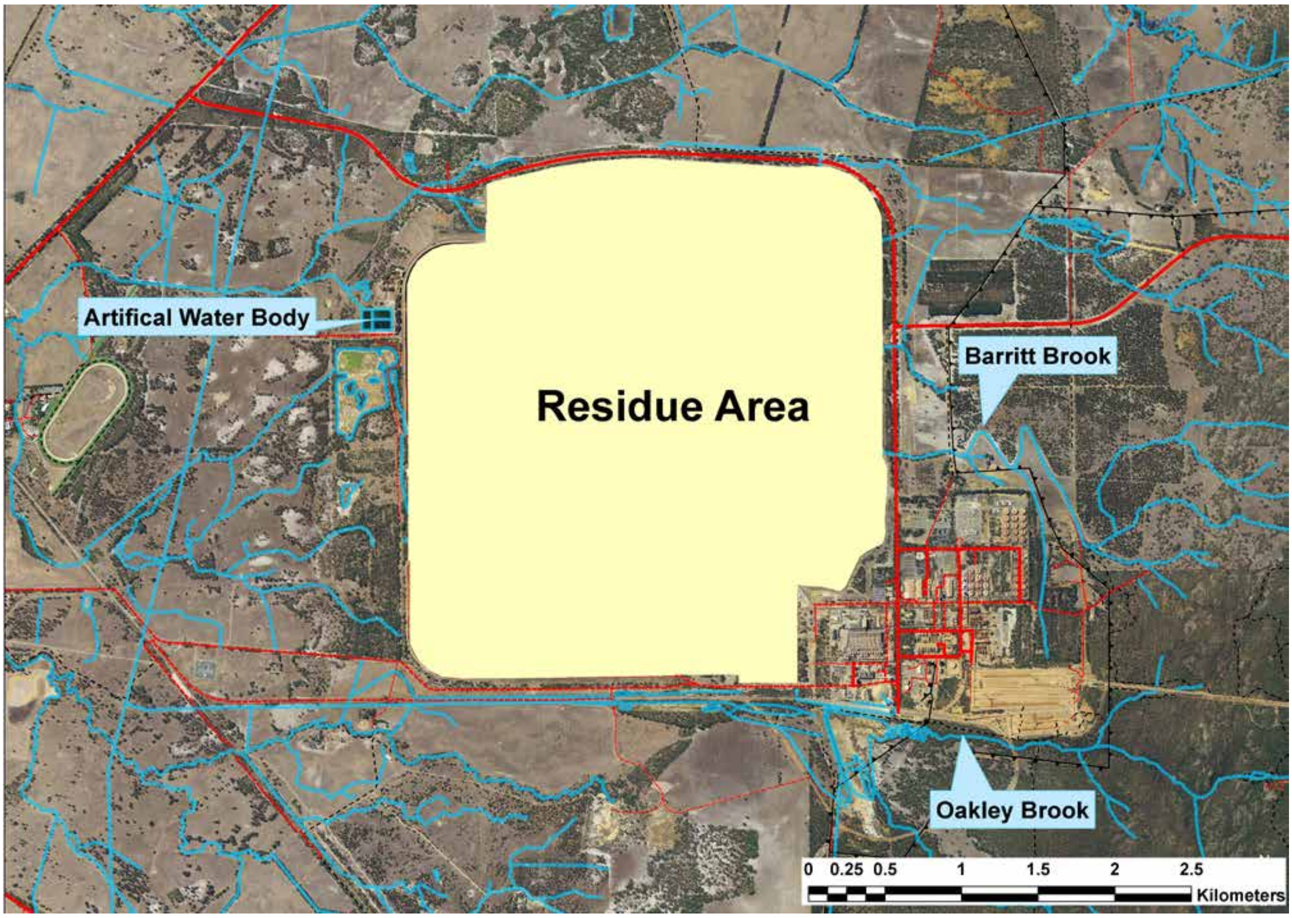


Figure 6-2: Surface water and catchment map.

6.4 Flora

The vegetation surrounding the Pinjarra Refinery was cleared many years before the construction of the refinery and the land used for cattle grazing.

As the Pinjarra Plain unit contains the best soils for pasture development and irrigation, there is no virgin vegetation left. Relict wooded areas would have been selectively culled for timber during the earlier years of settlement and their original shrub and ground layers have been replaced by pasture plants (Beard 1990).

Since 1992 substantial revegetation work has been conducted within the refinery site, with a focus on establishing native vegetation corridors, primarily along natural watercourses and roads. Comprehensive reviews of vegetation are conducted to evaluate changes over time. These surveys have identified one species, Synaphea stenobola, that is on the Department of Parks and Wildlife (DPaW) declared rare flora species list. A protection program to safeguard this species has been established in consultation with DPaW.

A level 2 flora and vegetation assessment was undertaken in December 2012 by Mattiske over the areas of remnant bush land surrounding Pinjarra Refinery. In general, the condition of remnant vegetation surveyed during this survey was very good. There was little evidence of other forms of disturbance, such as grazing, in the majority of remnant sites. A total of 235 vascular plant taxa which are representative of 125 plant genera and 47 plant families were recorded within the quadrats. The relatively high species richness still reflects the diversity of habitats founds in the area. The majority of recorded taxa are widespread throughout the region.

6.5 Fauna

Prior to construction of the refinery, the presence of native fauna at the Pinjarra site was limited. Species diversity and populations were consistent with those expected on agricultural grazing lands. A land management program has been in place since 1992 which has focused on revegetating large areas surrounding the Pinjarra Refinery and residue area.

In 1994, Alcoa commissioned a vertebrate fauna survey of farmland and wetlands surrounding the Pinjarra Refinery. The survey had two purposes:

- To obtain accurate baseline data so that the needs of fauna could be taken into account in rehabilitation and habitat management programs, and
- To record the distribution and abundance of fauna so that the success of fauna management could be evaluated.

In 2002, 2005, 2008 and 2012 follow-up surveys were conducted. These were designed to assess changes in the fauna populations over time, and develop recommendations for ongoing management of fauna.

Alcoa engaged Environmental Management Services (EMS) in 2012 to undertake a level two fauna survey of the Pinjarra Refinery landholdings. This survey identified no new species for the coastal/scarp area. The survey comprised of 659 fauna captures consisting of 65 species.

The study identified four conservation significant fauna species occurring in the Pinjarra farmlands, including Carnaby's Cockatoo, Chuditch, Southern Brown Bandicoot and Rainbow Bee-eater.

The significance of the Pinjarra Refinery site for fauna appears to be strongly linked to the revegetated areas, Ridge Hill Shelf vegetation and the jarrah forest to the east (Environ, 2003).

6.6 Heritage

6.6.1 Aboriginal Heritage Sites

Surveys of heritage sites are carried out prior to any proposed changes to the refinery footprint. These surveys are conducted according to the Guidelines for Aboriginal Heritage Assessment released by the Minister for Aboriginal Affairs in October 1993 and involve the local Aboriginal people.

Horizon Heritage Management was engaged by Alcoa in September 2012 to undertake an ethnographic site identification survey for the Pinjarra Farmlands. The survey was undertaken with members of both the Bilya Noongar Organisation and the Winjan Corporation. No new ethnographic sites were identified under Section 5 of the Aboriginal Heritage Act 1972, however, the continuing existence of two registered sites was confirmed during the survey.

Given the presence of heritage sites within Pinjarra Farmlands, Alcoa will actively work with the local Aboriginal people and the DIA to ensure compliance with all heritage conservation requirements and protection of aboriginal heritage sites.

6.6.2 European Heritage Sites

While some European heritage sites are protected near the Jarrahdale and Huntly mines, the closest protected site to the Pinjarra Refinery is an airstrip just over one kilometre to the north of the residue area. This airstrip was used by a squadron of Beaufort Bomber aircraft crews during World War II.

The Fairbridge Farm School is also located within Alcoa's landholdings. The Farm School was established at the site in 1921 and closed in 1981. In 1993, Fairbridge began a re-development program. Funding has come in the form of grants from both the Australian and Western Australian Governments, sponsorship by corporations, including Alcoa, and by private donations.

All 50 buildings within Fairbridge are heritage listed, including the Chapel of the Holy Innocents and Fairbridge House.

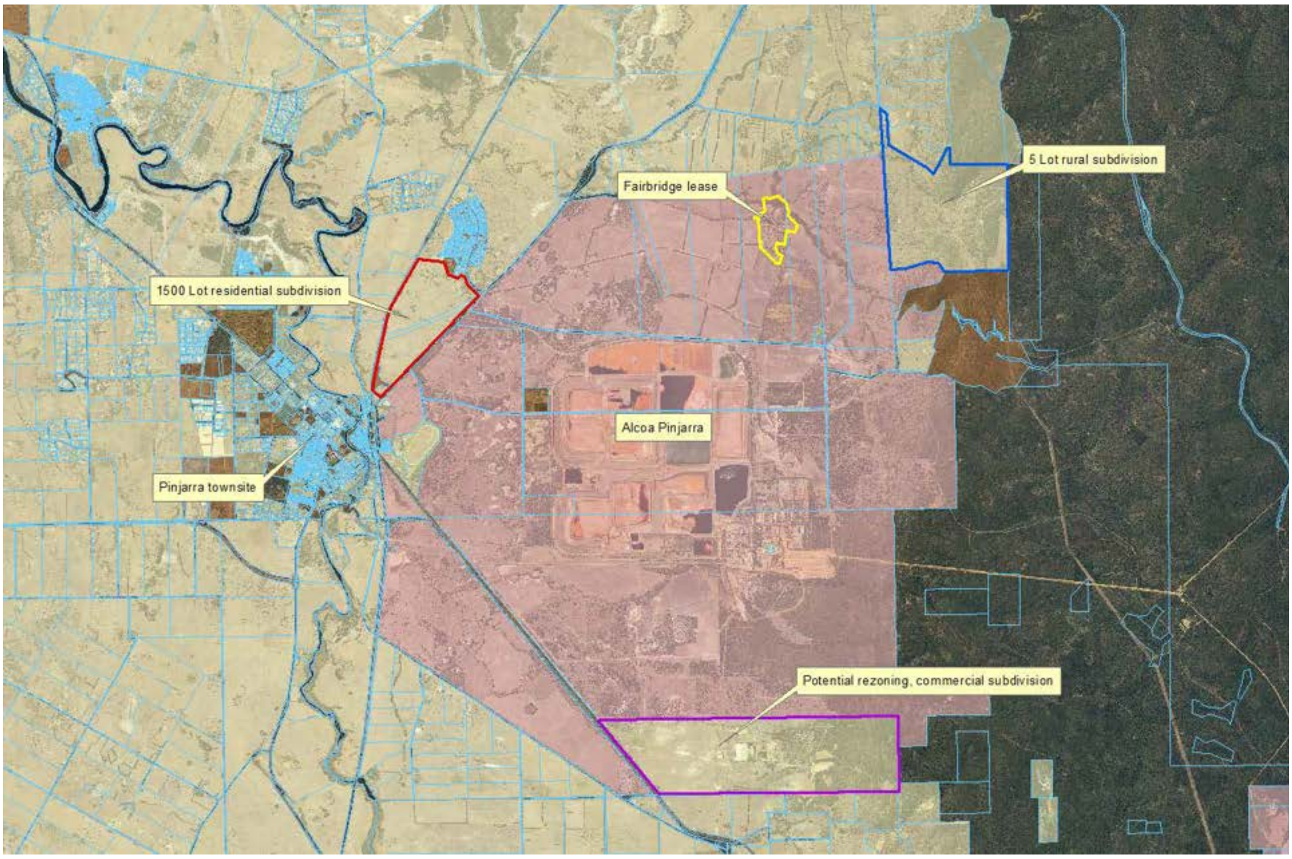


Figure 6-3: Pinjarra Refinery land ownership and surrounding development proposals.

6.7 Existing Land Use and Tenure

Alcoa's landholdings include the land required for residue storage, refinery activities and surrounding farmlands. The extent of Alcoa's land holdings are shown in pink on Figure 6-3.

Alcoa's original Pinjarra Refinery landholdings were purchased under a State Agreement Act to allow for future residue storage areas and refinery infrastructure, and to provide some separation between the refinery operations and neighbouring communities. Land not currently required for operational use is put to productive use as Alcoa Farmlands. There has not been any requirement for Alcoa to purchase a 'buffer' and none has ever been defined or incorporated in planning documents.

A portion of the land to the north of the main refinery site contains Fairbridge Village. Fairbridge Village is used for holiday accommodation, training, conventions and conferences, however, several of the Fairbridge Cottages are permanently occupied. Currently, a portion of Alcoa's landholdings are zoned "industrial" to allow for operation of the refinery and storage of residue, and "Special Use - Refinery Water storage and incidental infrastructure and equipment associated with the alumina refinery with the exclusion of Residue Storage Areas". The zoning boundaries are illustrated in Figure 8-1. Further industrial rezoning of Alcoa's rural landholdings may be required to allow expansion of the current residue storage area and associated infrastructure. The long term expansion of the residue area is planned entirely on Alcoa owned land.

Section 8 outlines Alcoa's long term development envelope and the strategy for its incorporation into State planning policies.

The bulk of Crown Land adjacent to the Pinjarra site is on the face of the Darling Escarpment. This land is State forest and is administered by the Department of Parks and Wildlife (DPaW). A wastewater treatment plant, which serves the Pinjarra township, is located immediately west of the residue area and is owned and operated by the Water Corporation of WA.

The majority of property surrounding Alcoa's site is privately owned. Historically the majority of surrounding landholdings have been zoned rural and used for agricultural purposes. However, in the recent past there has been increased interest in the development of surrounding land for a variety of uses, such as rural residential, special use – equestrian, and urban. A summary of current land developments and proposals is shown on Figure 6-3.

This changing situation has highlighted to Alcoa, local and state planning authorities, the need to clarify Alcoa's long term development intentions so that Alcoa's operations can be considered by the relevant government agencies when assessing development applications for neighbouring properties.

6.8 Local, Regional and State Planning Policies and Visions

The development of the LTRMS and final land use planning objectives are informed by current planning policies and visions for the region by the Western Australian Planning Commission, the Shire of Murray and the Peel Development Commission.

The need for Alcoa to continue to work with planning agencies to ensure long term development objectives for Alcoa's landholdings are understood and included in appropriate planning instruments was identified in the LTRMS SRG meetings.

Together with a commitment to best practice environmental controls, compatible land use planning is considered necessary to prevent conflict from encroachment of conflicting land uses. 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 any complaints.

6.8.1 State Planning Strategies and Structure Plans

State Planning Strategy 2050

The State Planning Strategy provides the strategic context for planning and development decisions throughout Western Australia. It is based on a framework of planning principles, strategic goals and State strategic directions that respond to the challenges and opportunities that drivers of change present for the future land-use planning and development of Western Australia.

The Strategy supports a collaborative approach to planning for the State's land availability, physical and social infrastructure, environment, economic development and security.

The State Planning Strategy 2050 guides and informs:

- local community plans, growth plans and local planning schemes and strategies with structure planning and development assessments,
- project approvals through the Government's Lead Agency Framework,
- planning for the coordination of physical and community infrastructure,
- region scheme amendments, regional planning and infrastructure frameworks, regional investments and service delivery programs, and
- investment proposals into areas and sectors of the State most likely to generate a return in the public interest.

Directions 2031 and Beyond

Directions 2031 and Beyond is the highest level spatial framework and strategic plan for the metropolitan Perth and Peel Region. One of its purposes is to set the framework for urban development until 2031 and beyond.

Draft Perth and Peel@3.5million

The Draft Perth and Peel@3.5million strategic suite of documents provide guidance on sustainable development over the next three decades to ensure the impact of urban growth on areas of environmental significance is minimised, to protect heritage, and to maximise the benefits of available land and existing infrastructure. The Draft Perth and Peel@3.5million has four planning and infrastructure frameworks for the Central, North-West, North-East and South Metropolitan Peel sub-regions.

Draft South Metropolitan Peel Sub-Regional Planning Framework

The Draft South Metropolitan Peel Sub-Regional Planning Framework (SMPSPF) was released for public comment in 2015. The draft SMPSPF identified proposed industrial investigation areas for the proposed residual storage areas. The Pinjarra Refinery industrial area is referred to in the Strategic Industry section, and the proposed future residue areas are shown as an "Industrial Investigation" area.

6.8.2 State Planning Policies

SPP4.1

State Planning Policy 4.1: State Industrial Buffer Policy (SPP4.1) was adopted in 1997 to provide a consistent Statewide approach for the protection and long-term security of industrial zones, transport terminals (including ports), other utilities and special uses.

SPP4.1 notes that industry and infrastructure, by their very nature, may generate a range of emissions of pollutants including noise, dust, gas, odour, fumes, lighting overspill as well as risk levels which may not be compatible with other land uses. As a result, most industries and infrastructure as well as some other uses need to be separated from residential areas and other sensitive uses with a buffer area to ensure that amenity (environmental quality, health and safety standards) is maintained at acceptable levels.

The specific objectives of SPP4.1 are:

- To provide a consistent State wide approach for the definition and securing of buffer areas around industry, infrastructure and some special uses.
- To protect industry, infrastructure and special uses from the encroachment of incompatible land uses.
- To provide for the safety and amenity of land uses surrounding industry, infrastructure and special uses.
- To recognise the interests of existing landowners within buffer areas who may be affected by residual emissions and risks, as well as the interests, needs and economic benefits of existing industry and infrastructure which may be affected by encroaching incompatible land uses.

6.8.3 Regional Scheme

Peel Regional Scheme

The Peel Region Scheme (PRS) is the principal land-use planning instrument for the Peel Region and allocates all land in the Peel Region into zones and reserves. Region planning schemes are designed to guide land-use planning in the long term through the use of broad zones and reservations, intended to minimise land use conflicts.

The Peel Region Scheme sets out the following purposes and aims:

- Provision for the zoning of land for living, working and rural land uses;
- Identification and protection of land having strategic importance for industrial and future urban use;
- Promotion of the sustainable development of land taking into account relevant environmental, social and economic factors; and
- Provision for industrial development in planned estates where land use conflicts and environmental impacts will be minimised and efficient production facilitated.

6.8.4 Relevant Local Planning Strategies

Hills Landscape Rural Planning Strategy (HLRPS)

The Hills Landscape Rural Planning Strategy (HLRPS) provides the 15-20 year strategic planning framework guiding development within the Shire of Murray, including the area east of South Western Highway and the proposed Pinjarra Bypass alignment. The document is underpinned by principles which relate to the conservation of agricultural land, the protection of the Darling Scarp's regional and local visual significance, the protection of remnant vegetation, and the co-location of Rural Residential development with existing urban centres.

These principles collectively form the Rural Planning Precinct Plan's objectives, which include:

- Protect the regionally and locally significant scenic qualities of the Darling Scarp;
- Protect important areas of remnant vegetation;
- Protect productive agricultural land within the study area from land uses and development that lead to its alienation or diminished productivity; and
- To inform long term strategic planning projects for the Shire of Murray.

6.8.5 Local Planning Scheme

Town Planning Scheme 4 (TPS4)

Town Planning Scheme 4 (TPS4) is the local planning scheme applicable to the Shire of Murray's municipal boundaries. TPS4 sets out the Shire's strategic direction through statutory provisions which prescribe how development and use of land may proceed.

Part 2 of TPS4 sets out the scheme's objectives, which include:

- To secure the amenity, health and convenience of the scheme area and its inhabitants;
- To encourage industrial uses to establish within the area set aside for that purpose; and
- To preserve the special environment associated with the lakes and waterways within the scheme area.

This scheme does not identify any buffer around Alcoa's Pinjarra Refinery operations.

7 Existing Environmental Issues and Management Strategies

7.1 Environmental Management Systems

Environmental issues at the residue area 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 environment management and certified to ISO 14001 in December 1999. Subsequently the EMS was extended to the remainder of the Pinjarra Refinery, which gained ISO 14001 certification in June 2002. The key elements of the system are:

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

The remainder of this section describes the key potential 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 Pinjarra LTRMS SRG.

The SRG members were provided with detailed information on the current issues and management strategies for the residue area to enable them to provide informed input into the development of the LTRMS.

7.2 Dust

7.2.1 Background

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

Dust generated from the residue area mostly consists of fine clay particles and sodium carbonate crystals. The sodium carbonate is precipitated on the surface of residue as entrained moisture evaporates. Residue dust is alkaline and could be an irritant to the eyes, nose, throat and lungs if high enough concentrations occurred, however, extensive monitoring data shows this is

very unlikely. If dry residue surfaces are not correctly managed, wind speeds in excess of 6.5 m/s (23 km/h) can lift and transport the fine residue and carbonate particles. 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.

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

October to April is the period when risk of airborne dust generation is potentially greatest, however Alcoa implements a detailed dust management program throughout the year irrespective of the season. In summer, the predominant winds are moderate to strong east-southeasterly and moderate southwesterly winds. Strong and gusty east-southeasterly often start around midnight, peaking between 2am and 5am, and abating mid-morning. The speed of these winds together with the higher ambient temperatures over summer, and therefore faster mud drying rates, require careful control mechanisms to prevent dust being released.

There were 19 complaints Alcoa received between 2010 and 2015 that related to dust. The number of residue dust complaints received since 2000 is shown in Figure 7-1 below.

Residue dust emissions are historically well within licence limits, with no exeedance of licence limits attributable to Alcoa between 2010 and 2015.

The SRG made a point of acknowledging the significant improvement in dust management practices since the 2011 review (Guiding Principle 1a). The sprinkler upgrade project completed in January 2009, together with increased operational focus on dust control measures, is perceived to have made a significant difference to overall dust performance.

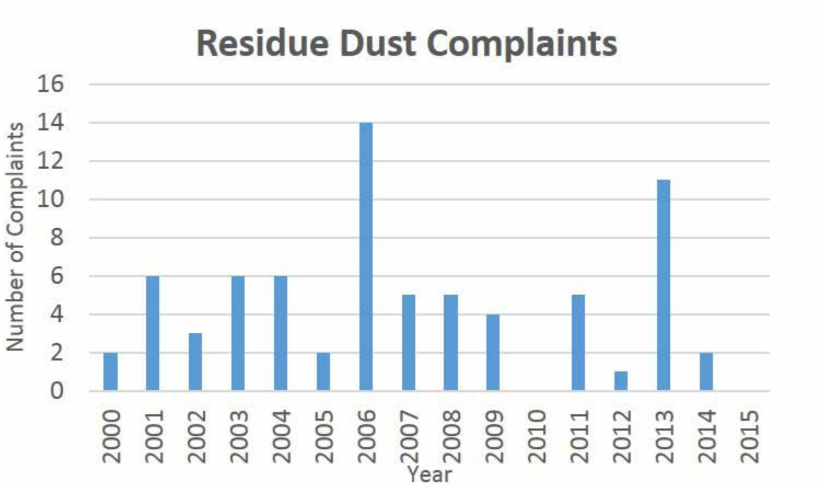


Figure 7-1: Complaints for residue dust from 2000 to 2015.
Note – only 4 of the 14 complaints registered in 2006 were attributable to Alcoa's operations.

7.2.2 Current Management Strategies

The nature of bauxite residue and the deposition and drying processes result 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 proactive and reactive strategies. Significant effort is invested in planning, implementing and monitoring the dust control measures to ensure best possible management 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 Pinjarra. An overview of each follows.

Long Term Controls (annual)

On an annual basis, dust control measures for the coming year are planned to ensure:

- dust control mechanisms are in place for any newly constructed or exposed embankments before stronger winds are forecast,
  - » 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 aggregate or mulch, and
- the frequency for application of dust suppressants to exposed surfaces, such as roadways, is specified.

Mid-Term Controls (weekly)

Dust management is reviewed at weekly meetings, which include the personnel involved in dust control. Weekly field inspections and surveys are carried out to check the effectiveness of dust controls and identify areas needing attention. These reviews monitor the ongoing risk of exposure to dust events.

A specialist consulting company supplies seven day and seasonal weather forecasts, which 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
- detailed investigations into exceedences of internal targets to prevent reoccurrences.

Day to Day Controls

On a daily basis the specialist consulting company also supplies a local rolling three day weather forecast, which includes a Dust Risk Rating that takes into account rainfall, 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 feedback from continuous dust monitors around the residue area. Internal alarms are triggered in the event of dust levels rising 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 Monitoring

Particles exist in the atmosphere contributed from a range of sources, both natural and man-made. Alcoa's dust monitoring program is in place to monitor the contribution of dust particles from residue areas to the local surrounding environment, as well as monitor overall ambient air quality in the area surrounding the Pinjarra Refinery.

Dust particles are present in a range of various size fractions with larger size fractions typically responsible for amenity impacts, whilst smaller size fractions are respirable and may therefore present potential health concerns. The terminology for dust size fractions monitored historically at Pinjarra is as follows:

Figure 7-2: Licensed dust monitoring locations.

- TSP (Total Suspended Particulate Matter) – particles with an aerodynamic diameter <50 μm, and
- PM_{10} (particulate matter <10 μm) – particles with an aerodynamic diameter <10 μm.

Currently TSP is monitored around the refinery and residue area at nine dust monitoring locations. PM_{10} was monitored at Pinjarra for a period in order to collect data for a residue dust health risk assessment (HRA), however this monitoring ceased in 2007. Results of the health risk assessment are discussed in Section 7.5.

Pinjarra Refinery's DER licence requires the continuous operation of High Volume Air Samplers (Hi-Vols) which produce daily averaged dust concentrations. These are located at three compliance sites: the Pinjarra Racecourse, Fairbridge Airstrip and Oakley South.

Figure 7-2 shows the current residue dust monitoring network.

Ambient Dust Standards

Ambient dust emissions monitoring at the Pinjarra residue area is carried out in accordance with DER licence conditions. These licence conditions specify the maximum target concentration of TSP at the premise boundary as a 24 hour average, as determined by continuous monitoring using high volume air samplers (Hi-Vols).

Dust Performance

All licensed dust monitoring data is presented in annual environment reports to the DER.

Between 2010 and 2015 there have been no exceedances of Alcoa's licence target. A number of exceedances of internal targets for the licensed monitors have been recorded and investigated during the period 2010-15. Of these exceedances, six were potentially attributable to Alcoa. Dust monitoring results are reviewed at each CCN meeting.

7.2.4 Residue Dust Studies

Following on from the Wagerup PM_{10} and $PM_{2.5}$ study performed 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 NEPM standards and assess the physical and chemical properties of residue dust. The information was then used in a quantitative HRA 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.

Impact of Expanded Residue Footprint on Dust Emissions

As a result of the identification of potential development areas via the life-of-mine planning process, as discussed in Section 8, modelling will be conducted on various expansion scenarios. Results will be used to confirm the suitability of the preferred development areas and to inform Alcoa's position on compatible land use development around our operations required to protect our ability to operate to our life-of-mine timeframes.

This modelling will also take into account the projected required stack heights on dust emissions for the various scenarios.

7.2.5 Guiding Principles and Alcoa's Commitments

In response to the information provided, the Pinjarra LTRMS SRG developed a number of Guiding Principles. Those related to the issue of dust are presented below, together with Alcoa's response.

Guiding Principle: 1a) Residue Dust Control and Improvement

The SRG acknowledges that dust control at Pinjarra residue has significantly improved since the last LTRMS.

Alcoa to maintain the current dust control measures and seek to research and implement improved methods of control, where possible.

Alcoa's Response

Alcoa is committed to maintaining our current dust control measures and seeking opportunities to improve the implementation of these measures. In addition we will continue to evaluate new dust control measures as they become available.

Guiding Principle: 1b) Dust – Reporting of Results

The SRG request dust monitoring results presented to the CCN include assessments against the internal targets, and that any changes to dust monitoring programs are discussed with, or presented to, the CCN.

Alcoa's Response

Alcoa accepts and agrees with this principle.

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), potential ammonia sources and others, and is an amenity issue of concern for the local community.

VOCs are a class of chemical compounds that are readily released from water or air emissions at normal temperatures. While some are contributors to odour (such as acetaldehyde, benzaldehyde and propanol), others are more of interest from a health perspective (eg formaldehyde, benzene and toluene).

There have been very few odour complaints at Pinjarra over recent years and none relating specifically to the residue area itself. The SRG advised that odour was not currently an issue of concern in the community.

7.3.2 Odour and VOC Monitoring Results

In 2004, odour and VOC emissions from various residue sources at Wagerup Refinery were measured directly for the first time. 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 process between the Wagerup and Pinjarra refineries these findings can be applied to Pinjarra.

Tests 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 were those receiving liquor at higher temperatures. For Pinjarra these are (in order of significance):

- Cooling pond,
- Super-thickener,
- Sand discharge pond,
- Drying beds (wet),
- Drying beds (dry), and
- Low concentration, cool liquid surfaces (such as Run-off Water Storage and Run-off Collection ponds).

The VOCs emitted at the highest rates from residue were (in order of significance):

- acetone,
- acetaldehyde, and
- 2-butanone (methyl ethyl ketone).

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 Current Management Strategies

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

There are currently no management strategies in place to actively manage VOC concentrations to the residue area via the cooling circuit.

7.3.4 Impact of Expanded Residue Footprint

It is expected that the direction of proposed future residue expansion to the northeast will directly influence the areas in which odour emissions may increase. Modelling will help determine the extent of increases for different sensitive premises.

Any increase in wind speed associated with an increase in stack height has the effect of diluting and dispersing odour. Therefore, with any height increase of the stack, the impact is likely to be a lessening of ambient odour from residue.

RSA10 Odour Impact

The construction of RSA10, within Pinjarra's current industrial zoned footprint, contributed a further 90 hectares of drying area. This represents an increase in total drying area for Pinjarra of approximately 27%. One of the commitments of the RSA10 Works Approval was to produce an Odour Assessment Plan. The objectives of the plans are to:

- » Determine worst case meteorological conditions for odour from the Refinery and/or Residue Storage Area to impact Pinjarra, North Pinjarra (Carcoola) or the undeveloped urban zone along South Western Highway between these two sites,
- » Establish baseline odour intensity levels at nearby receptors through a Baseline Field Odour Survey targeting worst case meteorological conditions, and
- » Determine if the operation of the new Residue Storage Area, RSA10 causes a perceptible increase in odour at these receptor locations under worst case meteorological conditions (Post RSA10 Commissioning Field Odour Survey).

An RSA10 pre-commissioning baseline odour survey was undertaken in 2014. Results showed that odour levels near sensitive receptors were generally low. Odour assessors were unable to distinguish refinery and residue odours at a distance from the refinery. The highest odour levels detected were to the north-east, close to the refinery. Some odour was also detected to the south and west of the refinery at distances of approximately four to six kilometres. Refinery odours were not detected at North Pinjarra. A post RSA10 commissioning field odour survey was conducted during late 2015 and early 2016. The post commissioning survey results indicated that the resulting odour observations were lower than predicted by the baseline odour survey, for both the maximum odour level and frequency. The post commissioning survey concluded that RSA 10 has not perceptibly increased ambient odour attributable to Alcoa's Pinjarra operations. The survey also concluded that odour levels at near sensitive receptors attributable to Alcoa's Pinjarra are low.

Cooling Pond Relocation

The impact of odour emissions from the Cooling Pond was considered in the decision to relocate the pond from its previous location. Emissions from the Cooling Pond in its current and previous location were modelled and provided to the DER as part of the Works Approval application process.

7.3.5 Guiding Principles and Alcoa's Commitments

In response to the information provided, the Pinjarra LTRMS SRG developed a number of Guiding Principles. Those related to the issue of odour and VOC emissions are presented below, together with Alcoa's response.

Guiding Principle: 3a) Odour - Significance

The SRG acknowledges that odour from residue is not currently considered a major issue for the community. However odour impacts of an expanded residue footprint, including wet lake relocations, should be considered.

Alcoa's Response

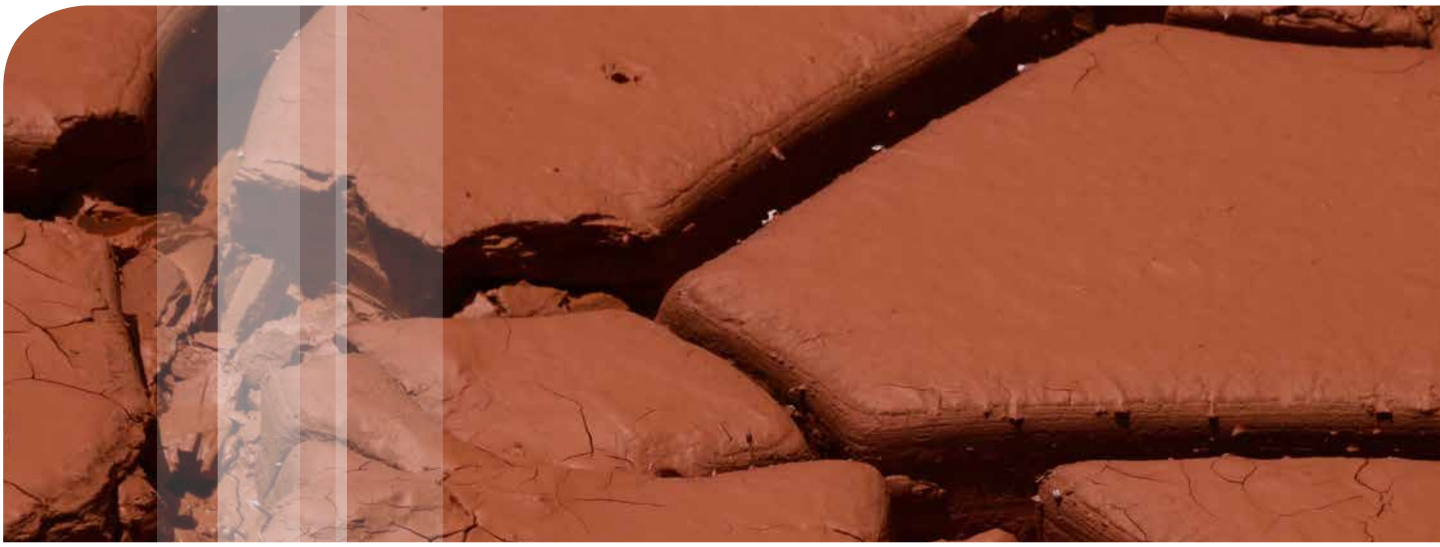
Odour impacts will be addressed in environmental and planning approval applications, as required.

Guiding Principle: 3b) Odour – Control and Improvement

Pinjarra Refinery to implement, where possible, any odour reduction strategies identified as part of Alcoa's broader research programs.

Alcoa's Response

Where opportunities for odour reduction from residue are identified as part of Alcoa's broader research programs, Pinjarra Refinery will assess these for their applicability, effectiveness, cost and benefit to its operations. Appropriate long term strategies for the implementation of odour reduction opportunities will be developed.



7.4 Radiation

7.4.1 Background

Radiation is widespread in our 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 has been studying the radiological aspects of its bauxite processing operations in Western Australia for more than 25 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 below the limit set for the general public. That is, readings have been more than 20 times less than the limit allowed for workers.

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 residue area, then the exposure received would be approximately 0.12 mSv above local background. This level is well within the limits that are applied to the general public and well below the background levels experienced in many residential areas on the Darling Scarp.

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.

Monitor	Gamma	Radon Progeny	Total Dose (Ann)	Standard
Residue Operator	<0.12	<0.12	<0.24	
Residue Maintainer	0.16	0.42	0.58	
Dozer Driver	0.12	<0.12	<0.24	1
Residue Super Thickener	<0.12	<0.11	<0.43	
RSA Central	<0.12	<0.10	<0.42	

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

7.4.3 Changes in Radiation Management Since 2011

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

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

There has been no additional monitoring focused on NORM since the previous campaign undertaken in 2008-09 where Alcoa performed NORM monitoring focused at mining and residue to provide information required to support a future application for exemption. The results, as shown in Table 7-1, are well below 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 has determined that the exposure to employees from radiation is below accepted health standards.

7.4.5 Impact of Expanded Residue Footprint

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 below exposure standards and less than natural background levels in many local residential areas.

7.4.6 Guiding Principles and Alcoa's Commitments

In response to the information provided, the Pinjarra LTRMS SRG determined that no Guiding Principles for radiation were required. Radiation management and reporting was considered to be adequately managed through government reporting processes.

7.5 Residue Emissions and Health

7.5.1 Background

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

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

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 our understanding of the contribution made to regional dust by the alumina refineries in WA. An independent Health Risk Assessment (HRA) was then performed to investigate the health risks associated with residue dust. In 2008 another HRA was undertaken for the Refinery and residue as a part of the Pinjarra Efficiency Upgrade (PEU) to 4.2 million tonnes per annum. Results of these HRAs were detailed in the 2011 Pinjarra LTRMS.

7.5.2 Health Risk Assessment Results

An 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 (one-hour & 24 hour averages),
- risk of long-term (chronic) health effects in relation to long term exposures (annual averages), and
- incremental risk of cancer in relation to long term exposures (annual averages over 70 years).

To increase confidence in the 2008 HRA for dust, the 2008 HRA 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 including northerly winds.

The 2008 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 were not available were not included in the 2008 HRA. The full details of the 2008 HRA (Environ, 2008) can be found on Alcoa's website: http://www.alcoa.com/australia/en/sustainability/health-wellbeing.asp

Based upon the results of the HRA it can be concluded that:

- the potential for emissions from the baseline or upgraded RSA to cause acute health effects presents no cause for concern,
- the acute Hazard Index (HI) is primarily driven by exposure to PM_{10}, not to individual metals in RSA dust,
- the potential for emissions from the baseline or upgraded RSA to cause chronic health effects represents no cause for concern, and
- the potential for emissions from the baseline or upgraded RSA to contribute to the incidence of cancer based on inhalation exposure is low, below the USEPA de minimis threshold of one in a million.

These results reinforce that Alcoa's operations are safe for both our 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 United States EPA of one in a million.

7.5.3 Impact of Expanded Residue Footprint

The most significant factor affecting the short term exposure contours around the residue area is the PM_{10} component of residue dust emissions.

Alcoa will update the dust modelling and HRA as required in the future to inform plans that involve making significant changes to the residue area.

In 2014, the Air Quality Model for the refinery was updated (Air Assessments, 2014) to reflect the proposed incremental increase in alumina production capacity to 5 million tonnes per annum (Mtpa). The model update included changes to the residue area since the previous modelling in 2008. The results from the updated model were used to revise the 2008 Pinjarra Refinery Health Risk Screening Assessment using the latest health protective guidelines.

The results of the revised 2014 Health Risk Screening Assessment (Environ, 2014) indicated that, in relation to the proposed incremental increase in the alumina production capacity of the Pinjarra Refinery up to 5 Mtpa, the potential for emissions to cause acute or chronic non-carcinogenic health effects as well as the potential for emissions to contribute to the incidence of cancer in the exposed population remains low. The results of the 2014 air modelling and health risk screening assessment were subjected to peer reviews (Pacific Environment Limited, 2015 and Weinstein, 2015), with the outcomes of the peer reviews submitted to the EPA. The results of the 2014 HRA were presented to the Pinjarra CCN in early 2016.

7.5.4 Guiding Principles and Commitments

In response to the information provided, the Pinjarra LTRMS SRG determined that a Guiding Principle relating to health impacts of residue dust was not required.

7.6 Oxalate

7.6.1 Background

Bauxite ore contains some organic matter (plant and animal matter) that forms oxalate during the alumina refining process. 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 which is commonly found in the environment and is not intrinsically harmful, the oxalate extracted from the refining process has a high caustic concentration and hence requires appropriate storage and treatment.

Prior to 2001, sodium oxalate was destroyed by incineration in a kiln, producing sodium carbonate, which is then converted to sodium hydroxide (caustic soda) and returned to the process. From 2001, sodium oxalate slurry was exported to Vanadium Australia's processing facilities at Windimurra for use as a fluxing agent. This allowed operation of the oxalate kiln to be ceased. In 2003 the Windimurra operation closed and a search for alternative markets was unsuccessful.

Before the oxalate kiln was recommissioned it required an upgrade to its emissions controls systems. This involved installation of a wet scrubber to remove particulates and a regenerative thermal oxidiser to destroy volatile organic compounds (VOCs) and carbon monoxide. In the period between Windimurra closing and the oxalate kiln being brought back online at Pinjarra in 2005, oxalate was reacted with lime and placed in the residue mud. This method of disposal was approved by the Department of Environment after a risk assessment showed that the risk of environmental or health impacts was very low. However this was not the preferred long term strategy for Alcoa as oxalate disposed with the residue returns impurities to the process, rather than removing them permanently.

7.6.2 Management Strategies

Currently the Pinjarra Refinery generates approximately 80 tonnes per day (tpd) of oxalate. This is predicted to rise to up to 85 – 95 tpd with increases in organic levels in bauxite and alumina production over the next five years.

There are currently two methods of managing sodium oxalate at Pinjarra Refinery; firstly via the oxalate kiln and secondly via the oxalate bio-removal plant. The oxalate bio- removal plant was commissioned in 2013 and uses naturally occurring biomass to convert sodium oxalate to sodium carbonate and sodium bicarbonate. The bio-removal plant consumes significantly less energy than the oxalate kiln. This is then converted to sodium hydroxide and returned to the process. Currently, excess oxalate is stored in lined ponds at the residue area. This will be recovered and processed as capacity becomes available.

7.6.3 Guiding Principles and Commitments

In response to the information provided, the Pinjarra LTRMS SRG developed one Guiding Principle relating to oxalate. This is presented below, together with Alcoa's response.

Guiding Principle: 6) Oxalate

The SRG notes that there is a commitment to recover all oxalate from residue storage ponds, and that the preferred method of destruction of the stored oxalate is via bi-ox, rather than via the oxalate kiln.

Alcoa's Response

Alcoa is committed to recovering stored oxalate from the residue area. Oxalate stored at residue is intended to be destroyed via the biological oxidation facility, however the continued operation of the oxalate kiln is required to treat ongoing oxalate production.

7.7 Water Use

7.7.1 Background

Pinjarra Refinery sources over 90% of its water from groundwater bores and surface water dams located within the refinery premises. The remainder comes from the Pinjarra waste water treatment plant, refinery sewage and rainfall that falls on the Pinjarra Refinery and residue area. At times of low annual rainfall, additional water may be sourced from the Water Corporation.

The refinery has been designed to operate an efficient 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, water bound within the residue mud and sand, and some seepage from the residue area. See Section 7.9 for further details. The largest use of water at the residue facilities is for operating sprinklers to control dust.

Process and potable water supplies at Pinjarra Refinery are sourced, under licence from the Department of Water (DoW), from six bores from the Cattamarra aquifer, beneath the Alcoa property. The Pinjarra Refinery currently draws groundwater from the Cattamarra aquifer under groundwater licences.

The refinery also holds a licence to take groundwater from the superficial aquifer under the refinery and residue areas. This licence allows for water to be drawn from the superficial aquifer by subliner drains and depressurising bores that reduce upwards pressure on the RSA liners and also by recovery bores or wells for alkali recovery.

Barritt Brook and Oakley Brook are natural, seasonal creek systems which cross the Alcoa Pinjarra Refinery property from east to west. Impoundments have been created on the main channels of Oakley and Barritt Brook as a contribution to plant water requirements. Uncontaminated stormwater flows into these impoundments and is then pumped to the fresh Water Storage Reservoir. Both systems discharge into the Murray River well beyond the Alcoa property boundary. The Lower Oakley Brook pumpback impoundment was designed to only retain winter surge volumes. Environmental flows are maintained by continuous release at the weir to ensure riparian rights are observed.

The three water supply impoundments are operated under surface water licences issued by the DoW.

In addition, treated water from the Water Corporation's Pinjarra wastewater treatment plant is also accepted into the residue Runoff Collection Pond (ROCP) and subsequently into the refinery process. In a typical year, Alcoa accepts approximately 300ML of treated water. This water conservation initiative was implemented in full consultation with the Department of Environment Regulation, and results in a significantly lower nutrient load in the Murray River, which leads to the Peel-Harvey Estuary.

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

7.7.2 Current Management Strategies

Operation of the residue sprinkler system contributes significantly to water usage volumes. While this results in effective dust management, Alcoa is also focused on maintaining dust performance while using water efficiently.

Alcoa committed to a water conservation program and participates in the Water Corporations' Water Efficiency Management Plan programme. The objectives of Alcoa's water efficiency action plan are to:

- Assess current water used 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.

Water efficiency achievements relevant to residue include:

- Increase in water harvesting from farmlands to reduce reliance on scheme water as a backup. The onsite dam capacity has been increased to capture more run-off from Alcoa's farmlands.
- Maintenance of the refinery water treatment plant to reduce reliance on scheme water as a backup. In 2013 a major replacement of the whole aeration tower at the water treatment plant was completed.
- Completion of a number of energy efficiency improvements to reduce vapour losses to the atmosphere in 2014.

A number of initiatives were reviewed or are undergoing investigation with the long term view of reducing fresh water usage. These include:

- Use of an alternative water supply from the Gordon Road wastewater treatment plant. The cost effectiveness of this project is dependent on other parties. While Alcoa is interested, the infrastructure would likely need to service and be funded by a broader customer group.
- Implementation of managed aquifer recharge and recovery to reduce natural evaporation losses. A hydro-geological feasibility study has been completed. A further review is to be undertaken to determine if recharge is a cost effective option.
- Implementation of residue filtration technology to recover more water from residue. Construction of a residue filtration facility at Kwinana Refinery is nearing completion and it will allow an assessment of the applicability of the technology to Pinjarra Refinery to be undertaken.

7.7.3 Impact of Expanded Residue Footprint

With a stable production rate, the amount of drying area will oscillate around a relatively constant area (new areas will increase the open area but will then be consumed over time until new areas are required to off-set the losses). In the event residue filtration is implemented at Pinjarra Refinery, the amount of drying area required is expected to reduce significantly.

7.7.4 Guiding Principles and Commitments

In response to the information provided, the Pinjarra LTRMS SRG developed a number of Guiding Principles. Those related to water use are presented below, together with Alcoa's response.

Guiding Principle: 5a) Water Use - Conservation

Alcoa to continue to conserve water through reuse and reduction initiatives, identification of alternative sources and commitment to their use.

Alcoa's Response

Alcoa accepts and agrees with this principle.

Guiding Principle: 5b) Water Use – Regional Water Requirements

The SRG encourages Alcoa, where practicable, to maximise the broader regional benefit of any future infrastructure projects.

Alcoa's Response

Alcoa accepts and agrees with this principle. We will cooperate with government initiatives for economic reuse of alternative water resources.

7.8 Surface Water

7.8.1 Background

The refinery has been designed to operate an efficient closed water circuit, which is supplemented for water losses. See Section 3.8 for further details. Stormwater that runs off the residue or refinery areas is characteristically alkaline. This renders the water unsuitable for direct discharge to the environment. Therefore all rainfall runoff from the refinery and residue area is collected and stored in lined ponds within the residue area for recycling via the refinery process as make-up water.

In addition, fresh water only leaves the refinery's operations via the fresh water storage dams. The surface streams in the immediate vicinity of the Pinjarra residue areas include Oakley and Barritt Brooks, which flow into the Murray River (see Figure 6-2).

7.8.2 Current Management Strategies

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

The residue area has a 100% surface water containment policy. Surface water runoff and underdrainage is collected in the ROCP and then pumped to the ROWS or Cooling Pond.

Under normal rainfall conditions water collected on the surface of the RSA is allowed to drain freely to the ROCP. Under severe storm conditions water may need to be retained in the RSAs by closing the decant weirs in order to prevent an unmanageable amount of water reporting to the ROCP. 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 12 to 13 day recovery period.

The ROWS pond is used to accommodate the surges in total water storage capacity (i.e. cooling lake and the ROCP) as the evaporation and rainfall vary throughout the year. This ensures that in exceptionally wet years, water collected from the refinery and residue areas will not exceed the residue area's storage capacity.

The overall stability of the residue storage facilities has been designed in accordance with international standards to accommodate both static and earthquake loadings. The structural integrity of water storage ponds and RSA embankments are inspected annually by a third party consultant.

Surface Water Monitoring

A surface water monitoring program is in place at the refinery to measure long term quality changes associated with refinery and neighbouring activities. It also provides data to ensure that abstraction levels do not exceed the water requirements of the local environment. Surface water monitoring results are collated and reported annually to the DER and the DoW.

Water collected at Oakley and Barritt Brooks has exhibited seasonal variations that parallel rainfall patterns at one of Alcoa's monitoring sites which is located upstream from the confluence of the

Murray River and Oakley Brook, and as such, provides baseline conditions prior to any influence from Alcoa's operations. Collected data indicates that Alcoa's operations have no measureable impact on water quality in the Murray River.

Flow data is obtained from v-notch weirs located near the junction of Barritt Brook and the South West Highway, the junction of Oakley Brook and the railway bridge near the Pinjarra Williams Road, and Oakley Brook upstream of the Oakley Brook detention dam. Each weir is equipped with a data logger to record stream levels which are used to calculate flow rates.

More detailed information relating to surface and groundwater quality can be found in the *Review of Groundwater and Surface Water Management* report which is submitted annually to the DER and the DoW.

7.8.3 Changes in Management Since 2011

To maintain the relevance of the surface water monitoring program, ongoing reviews of the relevance of the monitoring parameters and frequencies are undertaken (the latest round was undertaken in 2015).

7.8.4 Impact of Expanded Residue Footprint

An increased residue footprint requires an increased storm surge capacity and increased long term storage capacity for winter rainfall. The amount of required water storage is a function of the total residue footprint, as water is collected from RSAs, embankments and infrastructure areas to prevent any contamination leaving the site.

Future residue areas and associated water storage infrastructure will be constructed in accordance with the current strict residue engineering guidelines and controls outlined in Section 4.5, ensuring no additional likelihood of impact on surface water bodies.

7.8.5 Guiding Principles and Commitments

In response to the information provided, the Pinjarra LTRMS SRG chose not to develop any Guiding Principles relating solely to surface water. However Guiding Principle 4C, described in Section 7.8, refers to the protection of surface and groundwater through appropriate design and construction of future residue storage areas.

7.9 Groundwater Impacts

7.9.1 Background

Groundwater of useable quality is present in the superficial strata within the region of the existing and proposed residue deposits. The quantity and quality of this water generally renders it suitable for stock watering only.

A more significant groundwater resource (the Cattamarra Coal Measure) is present in a sub artesian aquifer approximately 150 metres beneath the surface. This water is good quality and is utilised by the refinery for potable and process make-up water. It is believed that this deep aquifer is recharged in the vicinity of the Darling Scarp, but in the vicinity of the residue area it is isolated from the surface by soils with very low permeability (Wainwright and Associates, 1984). The aquifer flows in a westerly direction and discharges into the Peel-Harvey Estuary.

The potential impact of residue leachate on ground water quality was recognised when the Pinjarra Refinery was built and as a result, the residue areas were located on areas of low-permeability clay soils.

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 Pinjarra.

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 the 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.

All RSAs have base drainage systems. These drainage systems provide a major defence against seepage to the ground water by substantially lowering the hydraulic head at the base of the deposit. All RSAs constructed since 1983 have included PVC or HDPE liners to further mitigate seepage. A schematic representation of RSA construction is provided in Figure 7-3.

7.9.2 Current Management Strategies

Alcoa has a comprehensive groundwater monitoring program to monitor changes to groundwater levels and quality. Any losses from the residue areas are typically characterised by elevated total dissolved salts and elevated pH in the groundwater. RSA10, the most recently constructed RSA at Pinjarra, was commissioned in 2015. RSA10 has a tri-liner consisting of a geosynthetic clay liner sandwiched between two layers of HDPE.

Alcoa provided a report in 2007 to the DER in accordance with the requirements of the Contaminated Sites Act 2003, that identified the residue area as "Possibly Contaminated – investigation required" due to seepage from the RSAs. Alcoa is committed to implementing the requirements of the Contaminated Sites Act 2003, in line with DER Contaminated Sites Guidelines, as agreed between Alcoa and the DER. Alcoa provides regular updates to stakeholders on the progress of these actions through consultation processes such as the CCN, the Pinjarra Refinery EIP, and the Pinjarra Refinery LTRMS SRG.

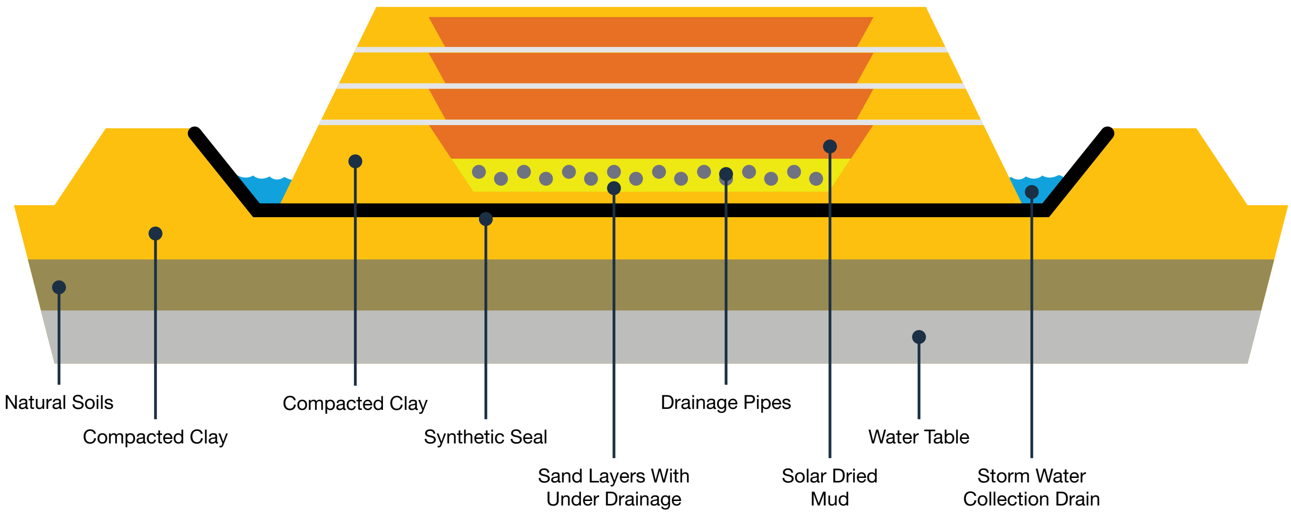


Figure 7-3: Schematic showing construction method of residue drying beds.

The following areas within the residue area are identified to have elevated alkalinity:

- The western dyke of the ROWS Pond,
- The northern dyke of RSA1,
- The northwestern corner of RSA 2, and
- The southwestern corner of RSA 5.

A summary of the strategies put in place to address these issues follows.

ROWS Pond

Depressurising bores and a sub-liner drainage system is in place for the ROWS pond to reduce upward pressure from groundwater in the area and prevent damage to the pond's base seal. Water levels in bores adjacent to the ROWS Pond are monitored as part of the groundwater level management program.

Localised elevated alkalinity has been found in one lower superficial aquifer bore on the western embankment of the ROWS Pond. The plume is moving northwest from the ROWS pond and its shape indicates a localised source. Alcoa is investigating the installation of a down gradient recovery system, possibly located on the northwest side of RSA10.

RSA1 (Previous Cooling Pond)

RSA1 was the first residue area constructed at Pinjarra Refinery and was commissioned in 1972. This pond was built to the standards of the day, which involved construction of the embankments and floor with low-permeable clayey material. Plastic liner was placed over an area of the floor where higher permeability material was found. As other RSAs were constructed, RSA1 became the cooling water pond, and after dry stacking was implemented, it was used as a 'bypass' area.

Over the 37-year period of operation an alkaline plume has developed in the superficial formation beneath RSA1. The plume's movement has been restricted by the low permeability of the strata and natural chemical attenuation of the plume by aquifer materials.

RSA1 North has now been relined as part of a conversion project and RSA1 South will also be converted in the future. This is to allow dry stacking to take place and its functionality has been replaced by construction of a new, composite lined Cooling Pond.

As part of the conversion of RSA1 to dry stacking a number of actions are required to de-liquor the pond and address the groundwater contamination. These actions, which have been approved by the DER as part of the Works Approval for the pond conversion, are described in Section 8.5.3.2.

RSA2

RSA2 is one of the older RSAs and does not have an underdrainage system.

Localised elevated alkalinity has been identified in the upper superficial aquifer bores located around the northwestern corner of RSA2. The data from this area suggest a source of alkaline leakage into the upper superficial formations in the northwestern part of RSA2.

The extent of the plume in the vicinity of RSA2 and the requirement for remediation is being investigated.

RSA5

In 2007, monitoring data in two upper superficial aquifer bores on the southwest corner of RSA5 indicated a sudden large increase in alkalinity and electrical conductivity, however, only a small increase in pH was seen. This indicated a possible local source of alkaline leakage. Subsequent monitoring has shown parameters in one bore increasing and the other decreasing. Ongoing monitoring of these bores is scheduled with the need for future investigations to be determined.

7.9.3 Changes in Management Since 2011

Alcoa has established and maintains an intensive groundwater monitoring network consisting of residue area perimeter bores and regional bores.

Changes in groundwater quality resulting from impact by Bayer liquor or residue leachate are primarily assessed using pH, alkalinity, and electrical conductivity. Of these, alkalinity is considered the most definitive. Alkalinity is a measure of the quantitative capacity of a water solution to neutralise an acid.

Detailed information relating to the groundwater monitoring program and current groundwater quality can be found in the Review of Groundwater and Surface Water Management Report (Rockwater, 2015) which is submitted annually to the DER and the DoW.

To maintain the relevance of the groundwater monitoring program, ongoing reviews of the monitoring parameters and frequencies are undertaken.

With the construction of RSA10, monitoring bores located along the northern embankments of RSA6 and the ROWS pond were decommissioned. New monitoring bores were installed on the perimeter embankments of RSA10 and were added to the ongoing monitoring schedule.

7.9.4 Impact of Expanded Residue Footprint

Expansion of the residue footprint increases the area over which there is a potential risk to the groundwater from caustic leakage. For this reason there are strict standards governing the design and construction of new residue areas. Significant improvements in residue design and construction techniques have been made in recent years, with the inclusion of base drainage and clay-geomembrane liners into standard design. The success of these improvements is reflected by groundwater monitoring results. Groundwater monitoring systems will continue to be constructed for new residue areas to ensure their performance can be monitored and managed appropriately.

Current design, operational control and monitoring systems in place are demonstrated to be effective in minimising the risk of any new residue areas on the groundwater.

7.9.5 Guiding Principles and Commitments

In response to the information provided, the Pinjarra LTRMS SRG developed a number of Guiding Principles. Those related to groundwater are presented below, together with Alcoa's response.

Guiding Principle: 4a) Groundwater - Monitoring and Response

Alcoa will continue to monitor groundwater quality around the residue area to identify seepage and leaks from the residue areas.

Where leakage is identified, Alcoa is to commit to timely action to prevent migration of contamination from the footprint, where possible.

Alcoa's Response

Alcoa will continue to monitor groundwater quality around the residue area to identify any potential contamination issues. Where issues are identified, these will be investigated and appropriate management strategies developed to minimise their impact on the environment and prevent any impact on surrounding land/water users. As many of the monitoring bores are on the external perimeters of the residue area, it is often not possible to detect contamination until it reaches the external perimeter of the residue area. Monitoring results and progress on management strategies are reported to the DER annually in the Review of Groundwater and Surface Water Management report.

Guiding Principle: 4b) Groundwater – ROWS Remediation

The SRG notes the remediation strategy in place to address identified contamination under the ROWS pond (RSA7).

The SRG recommends the ROWS pond be considered as the priority over the Water Storage Pond for the next wet lake conversion, to allow contamination issues to be resolved.

Alcoa's Response

Currently the ROWS pond conversion is planned as the next wet lake conversion. However this is dependent on a number of factors including funding and the ability to obtain the necessary approvals in the required timeframe (rezoning, and environmental approvals).

Guiding Principle: 4c) Groundwater – Integrity of the Sealed System and Liquor Containment

Construction of all future residue drying areas at Pinjarra Refinery to be conducted in a manner that ensures safe and secure storage of residue and does not compromise ground water or surface water resources or restrict others' use.

Alcoa's Response

Alcoa accepts and agrees with this principle. The current construction method applied by Alcoa is designed to achieve this outcome.

7.10 Land Use Management and Visual Amenity

7.10.1 Background

Alcoa has significant landholdings around the refinery and residue area. Original landholdings were acquired under the Alumina Refinery (Pinjarra) Agreement Act 1969 to allow for future residue storage areas and refinery infrastructure and to provide some separation between the refinery operations and neighbouring communities. This land creates a visual buffer to the refinery and associated infrastructure. There was no government requirement to purchase a buffer and there is no buffer defined for planning purposes for the refinery.

For the landholdings required for residue storage in the medium to long term future, interim land use management strategies are in place. Three main strategies are in place to manage the current landholdings (not under residue) east of the South West Highway:

- agricultural production,
- ecological protection and restoration, and
- visual screening of Alcoa's operations.

Due to the relatively flat landscape surrounding the Pinjarra Refinery, and the volume of residue to be stored, the residue area is becoming a prominent feature on the local landscape. The area occupied by residue is also visible from viewpoints along the Darling Range.

From the plain adjacent to the residue areas, the perimeter embankment slopes are visible from some locations. However, the vertical dimension of the current deposits (approximately 45 metres above ground level), is low when compared to the Darling Range which rises to a height of just under 200 metres in the area east of the refinery.

The Pinjarra LTRMS SRG raised visual amenity as an important aspect and noted the residue area is visible from a number of locations other than major access routes. The preference is to blend the residue areas into the natural landscape.

7.10.2 Current Management Strategies

A Land Management Program at Pinjarra Refinery has been ongoing for the past 20 years and is focused primarily on the land surrounding the residue area. A number of ecological restoration and visual amenity projects have been undertaken. In some cases, these projects will require ongoing maintenance and management to ensure their ongoing effectiveness. Weed control, feral animal management and fire control activities are also managed under the Land Management Program.

As part of Alcoa's visual amenity planning process, where the refinery creates a visual impact on the rural / natural landscape are identified and prioritised for visual amenity works.

The focus of visual amenity efforts will continue on the rehabilitation of external residue batters which will be increasingly visible as the height of the residue area increases. However landscape planting is also undertaken along roadsides and in farmland areas to complement this.

It is acknowledged that there are locations on private properties surrounding the refinery from which the residue areas and the refinery are visible. Embankment rehabilitation will continue to minimise the visual amenity impact from these locations.

7.10.3 Future Management Changes

It is recognised that work to screen the expanding residue area from the community and to blend the residue areas into the surrounding landscape will be ongoing.

While the benefits of modifying embankment shape will continue to be assessed on a case by case basis, Alcoa believes that the most effective way to incorporate the residue area into the local surroundings is through appropriate revegetation of the outer slopes. Natural variability to the appearance of slopes is hoped to be achieved through vegetation selection.

Residue revegetation programs are outlined in Section 7.11.

7.10.4 Impact of Expanded Residue Footprint

The impact on visual amenity of an expanded residue area depends on the proposed layout and height of the residue areas. Alcoa's visual amenity planning process is continually reviewed in line with the long term expansion plans and additional planting may be required to screen planned future infrastructure, preferably well before it is constructed. Future development footprint options take into consideration the positioning of current visual barriers.

7.10.5 Guiding Principles and Commitments

In response to the information provided, the Pinjarra LTRMS SRG developed a number of Guiding Principles. Those related to visual amenity are presented below, together with Alcoa's response.

Guiding Principle: 8a) Visual Amenity – Reporting and Review

The SRG supports the implementation and ongoing review and update of the Visual Amenity Plan.

The SRG requests any updates to the Plan be reviewed by, or discussed with, the CCN and an annual report on the implementation of the plan is provided to the CCN.

The SRG notes that the residue area is more visible from locations at a greater distance and height than the major access routes identified in the Visual Amenity Plan. Although screening from these vantage points is not necessarily possible, the visual amenity impact from other locations should be noted.

Alcoa's Response

Alcoa accepts and agrees with this principle.

Guiding Principle: 8b) Visual Amenity – Definition of Buffer

The SRG notes that the purpose of any 'buffer' around the residue area needs to be well understood. There is a perception among some that the sole purpose of a 'buffer' is for planting trees. While visual amenity plantings should be a key component of compatible land use, the SRG notes this is not the sole purpose of a buffer.

Alcoa's Response

Alcoa accepts and agrees with this principle.

Guiding Principle: 8c) Visual Amenity – Revegetation Screening

Alcoa to identify proactive opportunities to enhance and improve visual amenity through revegetation screening.

e.g. Between the residue area and Fairbridge.

e.g. Between the residue area and South West Highway.

Alcoa's Response

Alcoa accepts and agrees with this principle. Alcoa has a WA wide visual amenity lead team that meets regularly to review planning and progress with visual amenity plantings. The identified opportunities will be included in the Pinjarra Visual Amenity Plan.

Guiding Principle: 8d) Visual Amenity – Amend Shape of Residue Storage Area

Alcoa to investigate opportunities to amend the rectilinear form of RSAs to make them resemble a 'rolling hill' rather than the current rectangular style landform.

Alcoa's Response

Alcoa will consider this suggestion during the design phase of future embankment lifts. It should be noted that changing the shape of the residue areas can introduce significant additional cost into the operations. Our preference is to use shrub and tree plantings to break up the linear profile of the residue areas. The slope of the outer embankments is also reduced to 1:6 to provide more natural profile for the areas. The effectiveness of this approach is well demonstrated on the eastern side of the Kwinana residue area, adjacent to the Kwinana Freeway.

Plate 7-2: Current landscape, including the existing residue area.

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 batters of the upstream sand embankments. Final rehabilitation is the final sand spreading, contour shaping, revegetation and dewatering of the residue after closure of an RSA.

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 rehabilitation work undertaken at the Pinjarra residue area is on external embankments (external embankments are embankments on the boundary of the life-of-mine 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 residue 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. Leaching of the sand prior to final revegetation occurs with within the confines of the residue area, and all leachate is collected and returned to the refinery water circuit. Refer to Sections 3.8 and 9.3 for information about leachate management.

Pinjarra's existing rehabilitation program for residue areas uses native species, primarily found on limestone outcrops and in coastal heath lands.

The incorporation of gypsum (Stage 1, Figure 7-4) 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 7-4). 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 7-4).

The final step in rehabilitation operations is the hand planting of tree, shrub and groundcover seedlings at an approximate density of 1,200 stems/ha. (Stage 4, Figure 7-4). The native species used are adapted to the local climatic conditions and draw the water they need from the residue deposit. Water extraction by native vegetation will assist in reducing the total volume of water that will eventually need to be treated prior to release or reuse at closure. Alcoa's residue rehabilitation research has shown that rooting depth and therefore available water is strongly linked to the depth of gypsum presence in the soil profile.

Fifteen months after residue rehabilitation has taken place botanical monitoring is undertaken to assess the performance of the rehabilitation. This botanical monitoring covers species diversity, species abundance and percent coverage. (Stage 5, Figure 7-4).

7.11.3 Further Research

Alcoa's residue research program is regularly reviewed. These reviews form a basis for future research directions aimed at developing a sustainable vegetation cover on RSAs, maximising establishment of native vegetation, and optimising water and fertiliser use. The primary aims of residue rehabilitation research are to:

(1) determine fundamental characteristics (chemical, physical and biological) of residue sand controlling water-nutrients-plant dynamics.

(2) continue to refine the residue rehabilitation prescription to produce a sustainable vegetation coversystem based on sound scientific principles in the most cost-effective manner.

(3) assist in developing strategies for long term management of operating and closed RSAs.

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 m^3/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 7-4: Residue rehabilitation process.

7.11.4 Guiding Principles and Commitments

The SRG's Guiding Principles regarding rehabilitation are presented below, together with Alcoa's response. However, further Guiding Principles focussed on final land use closure and rehabilitation are presented in Section 9.6.

Guiding Principle: 7a) Rehabilitation – Integration with Surrounding Environment

Alcoa aims its residue area rehabilitation research at producing healthy sustainable ecosystems that can provide habitats for native Western Australian fauna. Rehabilitated residue to be integrated with surrounding vegetation and local wetlands and creeks. The value of providing an east-west vegetation corridor should be considered in preparation for closure, using the rehabilitated external residue area embankments.

Alcoa's Response

Alcoa accepts and agrees with this principle. Integration of the residue area into the local environment will not be possible until operations cease. However, Alcoa will take measures to ensure that the revegetated embankments will be readily integrated into the local environment at this time.

Guiding Principle: 7b) Rehabilitation – Fauna Monitoring

Fauna in rehabilitated residue embankments and surrounding vegetation and wetlands should be monitored to determine the effectiveness of rehabilitation.

Alcoa's Response

Alcoa accepts and agrees with this principle.


ALCOA

8 Short and Medium Term Residue Development Strategies

8.1 Residue Planning and Design Framework

Alcoa is currently undertaking the comprehensive residue management planning processes for the short-term (5 year), medium term (25 years), and life of the current mining lease (life-of-mine, 2045). These planning processes give consideration to the guidance provided through the LTRMS SRG process. Mud drying, embankment 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 year residue management planning process.

Planning and design of all new residue facilities is completed in accordance with Alcoa's Bauxite Residue Management Standard as well as relevant regulatory standards and guidelines. In addition to outlining the process to be followed when selecting and confirming the social, environmental and engineering suitability of areas for new residue facilities, these documents prescribe minimum design standards for all new facilities. For instance, detailed analysis is completed to confirm that the short and long term stability of earthen embankments exceeds minimum requirements and investigations are completed to ensure that all storm water generated from the residue area in a 1:100 wet year is able to 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 while 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
- the availability of key equipment and contractors.

The plans presented in the LTRMS are therefore subject to change, particularly the timing and sequence. The five yearly review process undertaken 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 year plan presented in this document, additional consultation may be required.

This LTRMS identifies the:

- current projected residue footprint for 2016-2020,
- current proposed area over which the residue area may expand during the next 25 years (to 2040), and
- current preferred area over which the residue area may expand during the life-of-mine (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 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:

drying area required = tonnes mud per day x 100 days / mud density / pour depth

Alcoa is continuously looking for ways to reduce the number of days of required drying time, and hence the drying area required. If improved drying times can be achieved whilst maintaining the structural integrity of the residue areas, this would reduce the rate new residue areas are required. Alcoa recently trialled alternative amphirolling cycles and the use of flocculants to assist with residue dewatering.

A flocculant product called Rheomax was trialled. Rheomax is a polyacrylamide/acrylate mixture that is chemically equivalent to the flocculants currently used in the super-thickener. It was added at the end of the residue pipe at very low rates, just before the residue is deposited in the RSA. Unfortunately, these trials demonstrated that no significant reduction in drying time was achieved and the use of Rheomax was discontinued.

However, the trials of alternative amphirolling cycles were successful and changes were made to the amphirol operations as a result.

Alternative Storage Technologies and Processes

Alcoa is currently investigating the feasibility of introducing large scale filter presses to the Pinjarra Refinery. 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 Pinjarra Refinery's residue area, this could have a number of advantages:

- Residue operations could be sustained within the current footprint for approximately the next 20 years,
- Residue water use would be significantly reduced,
- Reduced potential to produce dust from the RSAs, and
- Reduced potential to impact groundwater.

Alcoa is currently installing the filtration process at the Kwinana Refinery, with commissioning due to commence in the first half of 2016. If the filtration process proves to be a success, Alcoa will investigate the feasibility of installing the filtration process at Pinjarra Refinery.

8.3.2 Future Planning

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 Section 8.5 are therefore based on the current residue storage techniques. Information on how these plans would be modified if residue filtration is introduced at Pinjarra Refinery are presented in Section 8.6.

8.3.3 Residue Storage Techniques Guiding Principles

In response to the information provided, the Pinjarra LTRMS SRG developed one Guiding Principle relating to residue storage techniques. This is presented below, together with Alcoa's response.

Guiding Principle: 15) Footprint Reduction Opportunities

The SRG requests Alcoa works towards implementing processes that will enable a reduction in the drying area required for Pinjarra's residue operations. The SRG notes that Alcoa is currently investigating the application of residue filtration technology. The SRG supports active consideration of implementing this technology. Progress in this evaluation should be reported to the CCN on a regular basis via the LTRMS update.

Alcoa's Response

Alcoa accepts and agrees with this principle. Pinjarra Refinery is currently investigating new technologies for additional residue storage, including residue filtration. Final adoption of the next residue storage technology will include a number of factors, including cost effectiveness.

Current Pinjarra Refinery Residue Area Layout

8.3.4 Residue Area Planning Considerations

As the mud elevation in RSAs 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 RSAs. 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.

The refinery has no defined statutory buffer at either local or state level, nor any requirement under the State Agreement Act or any other legislation to provide one. The provision of an adequate buffer for the refinery's operations was, and still is, intended by the State to be provided through appropriate compatible land use planning. Alcoa acknowledges that in order to inform compatible future land use planning at both a local and state level, the Shire of Murray and the Department of Planning require a clear indication of our future residue storage land use requirements. Accordingly, this LTRMS review has sought to identify an area into which we require the ability to be able to expand.

8.4 Future Development

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.

A range of options for the life-of-mine development direction for the refinery have been considered. The benefits and constraints to expanding the current residue footprint to the north, south, north-east and west of the current residue area have been considered and are discussed in further detail in Section 8.5.1.

The impact of stack height on visual amenity, dust and footprint area have also been taken into account.

8.5 Future Plans with Current Technology

This section details Alcoa's future residue plans based on the current storage techniques.

8.5.1 Life-of-Mine Construction Strategy (2045)

Development Direction

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

Northern Expansion

Alcoa and the SRG considered northerly expansion of the residue area suitable subject to some constraints. The extent of the northern expansion of the residue area is constrained by Fairbridge Village to the north, the township of North Pinjarra to the northwest, and Alcoa's property boundary to the northeast. Hence any northern expansion will only provide part of the required future residue area for the life-of-mine requirements.

Other issues requiring further investigation to the north include areas of aboriginal artefact scatter, European heritage sites, wetlands and the potential presence of declared rare flora.

Alcoa will seek to maximise the separation distance from Fairbridge Village and the cemetery. While the area identified in Figure 8-1 represents the maximum extent of northern development currently considered possible, on the basis of anticipated separation requirements from neighbours, Alcoa's ability to develop the whole of this area will be determined by our ability to adequately address the impacts of the environmental and heritage issues noted above.

East and Northeast Expansion

Alcoa and the SRG considered easterly expansion of the residue area suitable subject to some constraints. The extent of the eastern expansion of the residue area is constrained by Alcoa's property boundary, the topography of the area, and the cost and ability to relocate critical infrastructure currently located in the area. In addition to the cost and engineering constraints of the topography, development to the east would require relocation of the major gas pipelines and power lines. The cost and ability to move this infrastructure, together with the availability of alternate routes, requires further investigation.

While the area identified in Figure 8-1 represents the maximum extent of east and northeast development currently considered possible, Alcoa's ability to develop the whole of this area will be determined by our ability to cost effectively address the impacts of the environmental and infrastructure constraints noted above.

Southern Expansion

The southern expansion of the residue area is considered suitable subject to some potential constraints. The extent of any southern expansion of the residue area depends on whether a contiguous stack is able to be developed.

A contiguous stack would allow a more efficient stack design and reduce the overall residue area footprint. However this would only be possible if Oakley Brook is able to be significantly realigned, aboriginal artefacts identified in the area relocated, and the rail-loop to the refinery

Social	Economic	Environmental
» Potential amenity impacts on neighbours » Potential impact on heritage sites (Aboriginal and European) » Visual Amenity	» Cost of construction and associated infrastructure relocation » Efficiency of stack design » Flexibility to respond to uncertainty in compliance requirements	» Potential impact on ecological sensitive areas and species » Potential dust impacts » Water levels and contamination pathways » Ability to achieve necessary approvals

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

able to be realigned.

The ability to realign the Hotham Valley railway to the west, and to clear native vegetation to the east, will also determine the extent of available area for a southern expansion, regardless of whether it is a separate or contiguous stack.

The development of a separate stack would also require modelling to ensure projected stack heights would not tunnel wind between the two stacks towards Pinjarra.

The area proposed to the south, shown in Figure 8-1, does not represent the maximum extent of the southern development currently considered possible, but represents the area outer perimeter or land required in the event that development to the north and east is constrained and a separate stack is required to be developed south of Oakley Brook.

Western Expansion

Alcoa proposed, and the 2010 SRG supported, that construction of future RSAs between the current residue area and the township of Pinjarra was not a suitable option on the basis of the increased visual amenity impact, together with the potential difficulty of managing dust impacts to acceptable levels any closer to residents. The 2010 SRG agreed that the area west of the residue area would be suitable for relocation of Refinery Water storage infrastructure, such as the Run-Off Water Storage (ROWS) Pond and the Water Storage Reservoir (WSR), subject to acceptable odour modelling outcomes for the town. The Peel Region Scheme and Shire of Murray Town Planning Scheme No. 4 were amended in 2013 to facilitate this.

Preferred Strategy

In relation to the discussion on the preferred direction of an expanded residue footprint for the Life-of-Mine Strategy, the SRG and Alcoa agreed on the following general principles:

- Expansion of the drying area footprint should not go west due to the need to maintain the current distance between the RSAs and the Pinjarra townsite (this area was considered suitable for Refinery Water storage only),
- Expansion to the north and east were preferred, as this would allow a consolidated drying footprint to be developed in one area and provide the most efficient stack design (and hence smallest overall footprint), and
- Expansion to the south is an acceptable option, if required, to offset any loss of development area to the north and east as a result of potential environmental or development constraints. However, because of railway infrastructure and potential heritage and environmental constraints to the south, development of residue storage to the south would likely be in the form of a separate stack which would result in an increased total footprint of the residue area.

Although constraints to the south require further consideration to determine their feasibility of being overcome, the current view is that these constraints are greater than those to the north and east, and consequently development to the south is the least feasible and sustainable option. Development of RSAs to the west of the current residue storage footprint were not considered by the 2016 LTRMS SRG.

There is estimated to be between 380 and 430 Ha of land suitable for residue storage development to the north and east of the current industrial zoned residue footprint. The total area is estimated to be able to accommodate approximately 35 years of alumina production at current planned refinery rates under existing storage methods. If this entire north-eastern area is able to be developed it would be able to accommodate the current life-of-mine (to 2045) residue area requirements. Additional areas would be required if the mining lease is extended or the refinery production rate significantly increased. This scenario does not take into consideration the possibility of implementing residue filtration. In the event residue filtration is implemented the future residue area required is likely to be significantly reduced.

If further studies find the whole identified area to the north and east is not utilisable, then development of RSAs to the south will also be required within the life-of-mine timeframe. The extent of any southern expansion will depend on the extent of constraints to the north and east. It should be noted that if the development of a separate storage area is required to the south, a much larger footprint will be required to the south than the footprint that could have otherwise been utilised to the north or east.

If there is insufficient developable land available to the north and east and residue filtration is not implemented and a separate southern storage area is required south of Oakley Brook or the identified aboriginal heritage site, then the southernmost extent of the footprint required for the life-of-mine footprint may be required to extend further to Alcoa's southern property boundary. This will be reviewed in the next LTRMS review, when a decision on residue filtration will have been made and the extent of constraints to the north and east are better known.

Alcoa has developed a proposed life-of-mine development envelope as presented in Figure 8-1. This area reflects the most likely extent for development of residue storage within the current life-of-mine period (2045). The actual extent of the area required for storage and associated infrastructure within this period will be primarily affected by the extent of developmental constraints identified within the areas to the north and east, as explained above. The proposed area assumes maximum heights within the stack of between 60 metres and 80 metres above ground level.

The proposed western area is bounded by easements for high voltage power lines and the Dampier to Bunbury Natural Gas Pipeline. This area and has been included in the total residue footprint area to provide for additional water storage areas, such as the ROWS and fresh water storage facilities.

Height

The current residue strategy is to maximise stack heights because Alcoa believes this is the most sustainable option. Economically an increased stack height has the benefit of requiring less land to store residue, and hence reduces capital costs. Socially, increased stack heights allows greater separation distances from RSAs to neighbours and reduces the overall land area which may have long term planning constraints. Environmentally a reduced footprint reduces the area at risk of future groundwater contamination and supports a range of alternate use and land use options.

It is acknowledged that increased stack heights are likely to be more visible than lower stack height options, and may provide a greater challenge for dust management. Increased stack heights also require careful management of hydraulic head, leaching time and structural stability. However previous SRG's supported the principle of increased stack heights so long as management of these issues continued to improve. The current SRG acknowledged significant improvements in dust performance since the last LTRMS review and supported final stack heights of between 60 metres and 80 metres above ground level for the final residue landform.

8.5.1.1 Guiding Principles and Alcoa's Commitments

In response to the information presented, the Pinjarra LTRMS SRG developed five Guiding Principles relating to the Life of Mine Footprint. These are presented below, together with Alcoa's response.

Guiding Principle: 12a) Footprint Development – Life of Mine (2045)

The SRG notes the basis for developing new RSAs to the north and east of the current residue area is to maximise separation of these areas from the majority of existing neighbours, and that Alcoa's current strategy is to endeavour to maintain a 2 km separation from current residences in Carcoola/North Pinjarra where practicable, and a reasonable separation from the Fairbridge Village settlement and cemetery.

The SRG supports the logic of building the residue area to the north first, and then to the east, to allow cut from the east to be used to develop the Northern footprint.

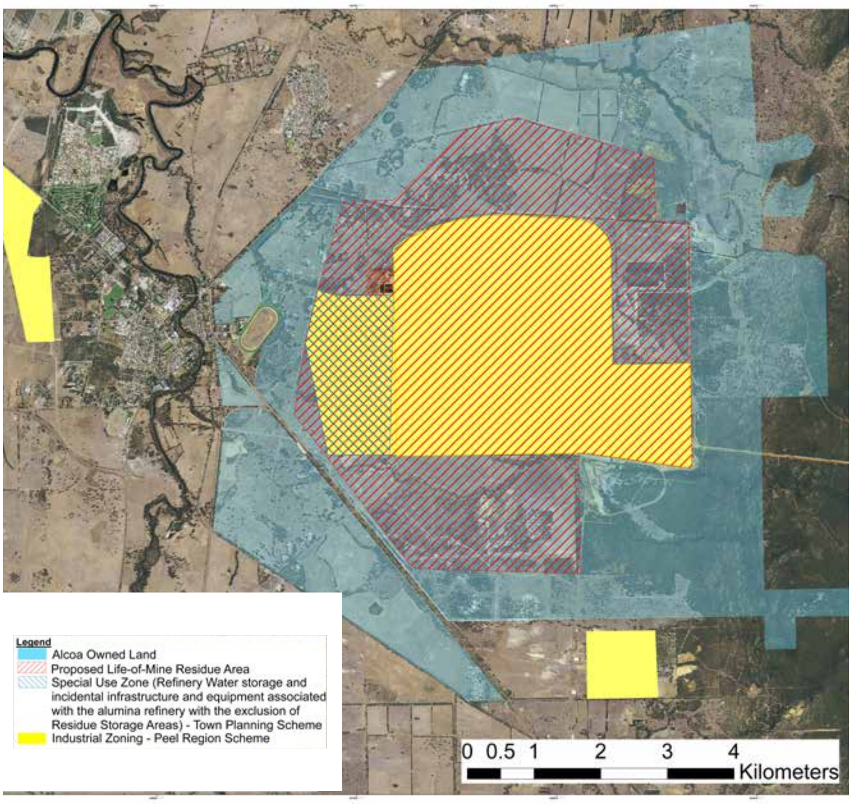


Figure 8-1 Proposed Life of Mine Development Area.

The DER and Shire of Murray note that further necessary assessments or approvals may be required.

Alcoa's Response

Alcoa accepts and agrees with this principle. The final development strategy will be subject to required approvals and a detailed assessment of the best overall option at the time the individual RSA development is required.

Guiding Principle: 12b) Footprint Development – Life of Mine (2045)

The SRG agrees it is desirable to present the life-of-mine footprint (2045) based on current technology and assumed production rates to provide certainty to other stakeholders. The SRG recommends that the proposed life-of-mine footprint be included in both regional and local strategic plans for the area to inform stakeholders of Alcoa's future plans.

The SRG recognises that rezoning will also be required to allow this land use.

Alcoa's Response

Alcoa accepts and agrees with this principle. As discussed during the LTRMS stakeholder engagement meetings, 2045 is the life of the current lease, but there are further provisions for the lease renewal which would extend the life-of-mine. Were these extensions to be granted, the life-of-mine footprint options would require further review.

Guiding Principle: 12c) Footprint Development – Life of Mine (2045)

The SRG notes that Alcoa will need to consider any strategic mineral resource areas and associated buffers in development of the final footprint.

Alcoa's Response

Alcoa accepts and agrees with this principle.

Guiding Principle: 13) Compatible Land Use Planning Around Alcoa's Operations

The SRG encourages Alcoa to continue working with relevant Local and State government authorities to ensure future land use development of surrounding properties are compatible with their current and planned operations.

Alcoa's Response

Alcoa accepts and agrees with this principle.

Guiding Principle: 14) Height

The SRG recognises that the life-of-mine footprint is based on residue heights of between 60 and 80m above ground level.

Alcoa's Response

Alcoa accepts and agrees with this principle.

8.5.2 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 residue area, 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, approximately 350 hectares of additional drying area is required. Projects designed to provide 110 hectares of the 350 hectares drying area required are currently planned to be constructed between 2016 and 2020 assuming residue filtration is not implemented, and are presented in Section 8.5.3. In the event residue filtration is implemented it is anticipated RSA14 will not need to be constructed.

The remaining mid-term residue construction activities required in the event residue filtration is not implemented include:

- construction of a new ROWS pond,
- conversion of RSA7 to residue storage,
- construction of a new Water Storage Reservoir (WSR),
- conversion of RSA8 to residue storage,
- construction of a new RSA12,
- construction of a new RSA13, and
- relocation of infrastructure, as required, to support the above projects.

There may be a requirement to obtain planning approvals to allow the construction of RSA12 and RSA13 within this timeframe.

The remaining mid-term residue construction activities required in the event residue filtration is implemented include:

- construction of a new ROWS pond,
- conversion of RSA7 to residue storage,
- construction of a new Water Storage Reservoir, and
- conversion of RSA8 to residue storage.

In developing a mid-term strategy, the key consideration is the final footprint of the residue area and detailing a sequence of development which supports flexibility in the final closure form. The proposed locations for the 350 hectares of potential additional greenfield RSAs required in the next 25 years cannot be considered in isolation of the longer term life-of-mine development requirements. Determining the life-of-mine development strategy is critical to informing the medium term development.

A range of options for the life-of-mine development direction for the refinery have been considered. The benefits and constraints to expanding the current residue footprint to the north, south, north-east and west of the current residue area have been considered and are discussed in further detail in Section 8.5. The impact of stack height on visual amenity, dust and footprint area have also been taken into account.

Although the range of potential future RSAs required for the next 25 years has been determined, the actual footprint for these areas will be confirmed following further studies of the area and any changes in residue storage technology. These studies, which are underway or planned to support any required planning applications and other required approvals, will identify any potential environmental or heritage constraints in the area. A more detailed sequencing of residue areas to the north and east should be possible in the next 5 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,
- implementation of residue filtration, and
- ability to locate wet lakes (Water Storage Reservoir and ROWS Pond) outside of the mid-term drying area footprint in the required timeframe.

8.5.2.1 Water Storage Reservoir Relocation and Conversion

The WSR currently provides storage for surface water from Oakley and Barritt Brooks, groundwater from licensed abstraction bores, good quality condensate from the refinery and on occasions, makeup 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 WSR is surrounded by current and future drying area footprint, preventing surrounding areas from being consolidated. Maintaining the WSR in its current location will increase the rate of loss of drying area as new internal embankments are built, bringing forward the requirement for new RSAs.

Options for the location of a new WSR have been investigated, and were discussed with the previous 2010 SRG. As the WSR is basically a fresh water dam, with the least potential of any residue infrastructure to impact on the local community, the preferred location was agreed to be west of the current residue drying area. This location also preserves areas to the north, south and north-east of the current footprint for future dry storage. The indicative location of WSR is shown in Figure 8-2.

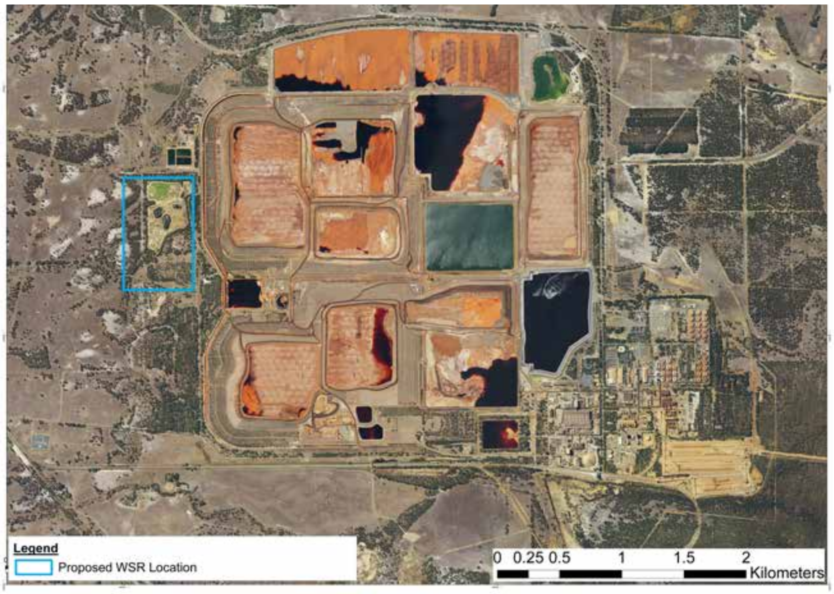


Figure 8-2: Proposed WSR location.

8.5.2.2 Planning Strategy to Support Future Residue Development Requirements

Rezoning of sections of Alcoa's landholdings from "rural" to "industrial" may be required under the Peel Region Scheme to allow construction of residue storage infrastructure in new areas. The Shire of Murray's Local Planning Scheme would then also be required to be updated to reflect the Peel Region Scheme.

8.5.2.3 Guiding Principles and Alcoa's Commitments

In response to the information presented, the Pinjarra LTRMS SRG developed one Guiding Principle relating to the mid-term construction strategy. This is presented below, together with Alcoa's response.

Guiding Principle: 11) ROWS and WSR Locations

The SRG notes the strategy for locating wet lakes to the west of the current residue area is designed to minimise the overall impact on the community from residue infrastructure, as it allows new RSAs to be developed further from the existing community.

The DER and the Shire of Murray note that further detailed assessments or approvals may be required.

Alcoa's Response

Alcoa accepts and agrees with this principle.

8.5.3 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,
- maintaining the water storage, surge capacity, cooling and process water supply functions for the refinery, ensuring they can service the increased residue area, and
- relocation of infrastructure required to support the provision of adequate residue drying and water storage capacity.

Over the period 2016-2020, the following potential new RSAs may be required to accommodate expected refinery production:

- conversion of RSA1S to an active drying area, providing approximately 35Ha of additional drying area,
- construction of a greenfield drying area, RSA11, within the current residue footprint, providing approximately 20Ha of additional drying area, and
- construction of a greenfield drying area, RSA14, to the east of the current residue footprint, which will provide approximately 65Ha of drying area, or alternatively the implementation of a new residue handling technology (such as residue filtration – see Section 8.6).

As outlined in Figure 8-3.

8.5.3.1 Business as Usual Construction Activities

The following 'business as usual' construction activities will be carried out over the period 2016 to 2020:

- 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 metres and 10 metres higher than the previous crest level, construction and/or relocation of infrastructure associated with the embankment lifts,
- construction of new underdrainage systems associated with hydraulic placement of sand in new embankment walls and/or stockpiles,

- installation of new decant structures, and/or relocation of existing decant structures, and associated pipework,
- extension/modification of mud and sand distribution pipework,
- extension/modification of the groundwater bore monitoring network,
- extension of sprinkler risers, and
- construction of new roads.

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

8.5.3.2 Cooling Pond Conversion

The second half of the conversion of RSA1S (formally the refinery cooling pond) to dry storage is expected to be completed by 2020.

The process for conversion of RSA1 has been subject to detailed environmental review by the DER via a Works Approval application. The conversion methodology is designed to reduce the source of existing groundwater contamination from the area and minimise any further contamination resulting from the area's ongoing use as a dry storage area.

The RSA will be filled with a mixture of residue mud and sand which will then be covered with a residue sand layer. An under-drainage system will then be installed on top of this deposit which will then be covered with a synthetic liner. The pressure of the residue stacked on top of the liner will then allow the liquid in the existing stack to be pushed up and out of the deposit, rather than down into the groundwater. The synthetic liner will minimise any additional contribution of liquor from the dry stacking operation.

This process will be aided by the installation of wick drains which will feed into the underdrainage layer to relieve the pore pressure in the existing material. The wick drains will increase the permeability of the mud and speed up the consolidation process, allowing the entrained liquid within the stack to be removed more quickly. In addition, sediment de-liquoring will reduce leakage from the pond after the RSA conversion is complete.

8.5.3.3 RSA11 Construction

The indicative size and location of RSA11 is shown in Figure 8-3. The exact location and size will be accurately reflected in the required statutory approval applications after detail design is complete.

8.5.3.4 Guiding Principles and Alcoa's Commitments

In response to the information presented, the Pinjarra LTRMS SRG developed one Guiding Principle relating to the short term construction strategy. This is presented below, together with Alcoa's response.

Guiding Principle: 10) Footprint Development (5-9 years)

The SRG encourages Alcoa to convert the ROWS pond prior to additional greenfield developments.

Alcoa's Response

Alcoa will consider this suggestion when updating the residue master plan. The current master plan flags the possible construction of a small (20 Ha) greenfields RSA in the north east corner of the existing residue area (east of RSA10) as the earliest opportunity to reduce the current drying area deficit. Maintaining adequate drying area is critical to the long-term stability of the residue area.

8.6 Future Plans with Residue Filtration

If investigations determine that residue filtration is a feasible option for Pinjarra Refinery, Alcoa would look to develop a filtration facility at Pinjarra Refinery within the period covered by this LTRMS.

This section details Alcoa's future residue plans based on the implementation of residue filtration

8.6.1 About Filtration

Pinjarra Refinery is currently undertaking a feasibility assessment on new technology for residue storage (residue filtration). The filtration process produces a dry residue cake by filtering mud slurry through a membrane.

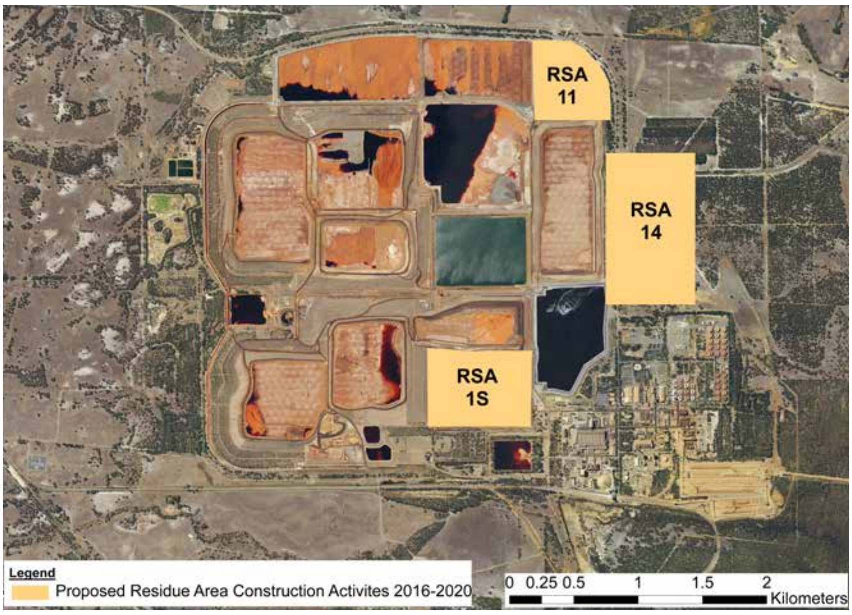


Figure 8-3: 2016-2020 Residue area construction activities.

The technology Alcoa is evaluating is called "plate and frame" pressure filtration. The introduction of filtration to Pinjarra's residue operations would involve commissioning a filtration building and mechanical system to place the dried mud in the RSAs (a conveyor system and mechanical spreading equipment).

Alcoa has been regarded as the global benchmark in bauxite residue storage and will be the first major mining company in Australia to introduce residue filtration with a facility currently under construction at Kwinana Refinery. Residue filtration is expected to provide a number of potential benefits including:

- a reduction in water usage,
- a reduction in the future residue footprint,
- improved residue dam stability,
- a reduction in dust potential from residue storage areas, and
- reduction of residue storage costs.

The location of infrastructure for the potential residue filtration facility has not been finalised. The majority of the conveying and dried residue handling system will be located inside the current residue storage footprint. Two possible locations for a residue filtration equipment building have been identified for more detailed evaluation – on the western side adjacent to the existing ROCP (inside the current industrial zoned area) and on the eastern side of the existing residue storage area (in an area that may require rezoning). These areas are shown above in Figure 8-4.

8.6.2 Life-of-Mine Construction Strategy (2045) with Filtration

8.6.2.1 Requirement for Life-of-Mine Land Use Planning

Alcoa currently has sufficient industrial zoned land to provide RSAs for the life-of-mine if a filtration facility is developed and fully implemented. This is based on the assumption the RSAs are developed to 80 metres above ground level, and that the existing ROWS Pond and WSR are relocated.

8.6.3 Mid-Term Construction Strategy (25-years) with Filtration

The key construction issues to be managed within the mid-term strategy include:

- maintaining the residue storage 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 RSAs, and
- relocation of infrastructure required to support the provision of adequate residue and water storage capacity.

The mid-term residue construction activities that will be required with the development and implementation of residue filtration include:

- construction of a new ROWS pond,
- conversion of RSA7 to residue storage,
- construction of a new WSR,
- conversion of RSA8 to residue storage, and
- relocation of infrastructure, as required, to support the above projects.

New RSAs 12-14 will no longer be required.

8.6.3.1 Water Storage Reservoir Relocation and Conversion

The Water Storage Reservoir (WSR) currently provides storage for surface water from Oakley and Barritt Brooks,

As outlined in Section 8.5.2.1, Alcoa plans to relocate the WSR to allow the existing residue area to be consolidated. If filtration is introduced to Pinjarra Refinery, the WSR will still need to be relocated however this relocation would be delayed, most likely until 2032-34.

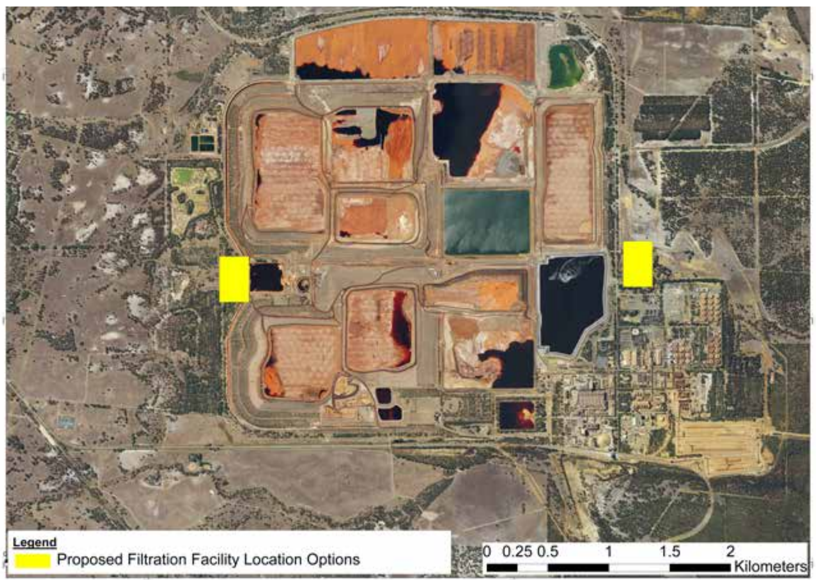


Figure 8-4: Proposed Filtration Facility Location Options.

8.6.4 Short Term Construction Strategy (5-7 years) with Filtration

Key issues to be managed within the short term strategy are:

- maintaining the residue storage 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 RSAs, and
- relocation of infrastructure required to support the provision of adequate residue water storage capacity.

Over the period 2016-2020, the following construction activities are planned:

- conversion of RSA1S to an active RSA, providing approximately 35Ha of additional RSA,
- construction of a greenfield drying area, RSA11, within the current residue footprint, providing approximately 20Ha of additional RSA, and
- construction and implementation of the new residue filtration and handling facility.

These areas can be seen in Figures 8-1, 8-2 and 8-3.

8.6.4.1 Business as Usual Construction Activities

The following 'business as usual' construction activities will be carried out over the period 2016 to 2020:

- 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 4m and 10m higher than the previous crest level, construction and/or relocation of infrastructure associated with the embankment lifts,
- construction of new underdrainage systems associated with hydraulic placement of sand in new embankment walls and/or stockpiles,
- installation of new decant structures, and/or relocation of existing decant structures, and associated pipework,
- extension/modification of mud and sand distribution pipework,
- extension/modification of the groundwater bore monitoring network,
- extension of sprinkler risers, and
- construction of new roads.

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

8.6.5 Guiding Principles and Alcoa's Commitments

The Guiding Principles developed by the Pinjarra LTRMS SRG have been presented in this LTRMS in the sections relating to Alcoa's future residue plans based on current technology. If investigations determine that residue filtration is a feasible option for Pinjarra Refinery and that it will be introduced, Alcoa will consider these Guiding Principles in the detailed development of the revised plans for the Pinjarra residue area.

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 Pinjarra LTRMS SRG for closure.

The process of defining the closure strategy will be ongoing. Final closure of the Pinjarra 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 de-commissioned residue areas should:

- have the capability to be used for productive community benefit,
- be safe and self-sustaining structures in the long term, and
- allow future access to residue for alternate uses.

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

9.1 Closure Strategy Options

The rehabilitation of the residue deposits will be ongoing during the operating life of the refinery. The perimeter embankments will be rehabilitated as the height of the stack grows, and revegetation of the surface of the RSAs will occur as each reaches its nominated final elevation. At the time of refinery closure, much of the rehabilitation will be complete with only minimal 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 a 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 for some further period of time if it is to be released to the environment.

9.2 Current Closure Strategy

Based upon current storage technology and the experience Alcoa has gained over the past 50 years in Western Australia, the company presently believes that continued leaching of the deposit beyond the time of closure is the preferred approach for closure of bauxite residue deposits.

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 suitable liner at the base of the stack. Residue 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 safely 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 currently unknown. 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 wider 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 focussed on establishing a native vegetation cover using 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.

Alcoa has undertaken research to quantify the soil-water plant dynamics in residue rehabilitation. This research is designed to inform the closure cover vegetation options and our understanding of the post closure water balance within the residue stack.

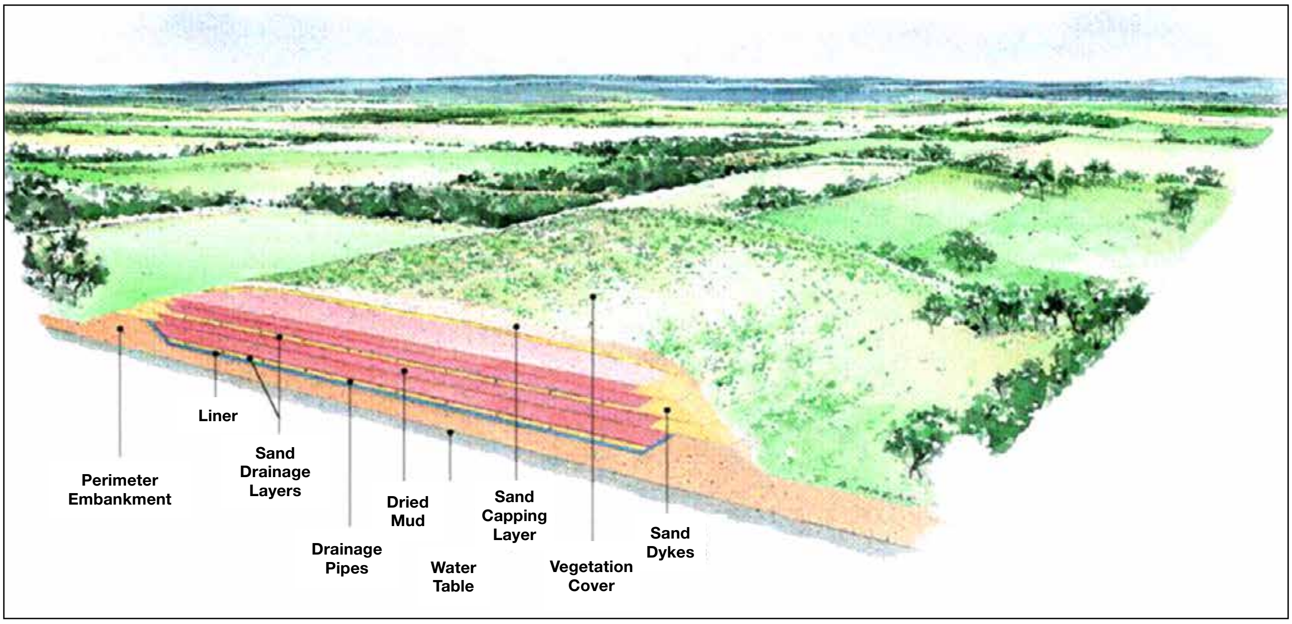


Figure 9-1: Preferred closure strategy for the residue areas at Pinjarra.

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 revegetated 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. Minimising the footprint of the residue area is the most effective way of reducing the volume of alkaline drainage water requiring ongoing management. The selection of vegetation planted on the closed area 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.

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

- treatment and discharge to the ocean or a local surface water source,
- managed aquifer recharge, and
- treatment and reuse (eg 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. It is anticipated that further analysis of water management options will be included in future LTRMS reviews.

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 be reduced. Water treatment options post closure will be impacted by Alcoa's ability to implement methods of pH reduction of residue or to manage alkalinity levels reporting to the residue area during active operations.

9.4 Future Land Use Options and Revegetation

The Pinjarra Refinery is located on land which was used for general agriculture prior to the construction of the refinery. Alcoa continues to graze cattle on parts of the property not currently occupied by the refinery or residue area.

The Pinjarra SRG stated its preference that, after closure and rehabilitation of the residue area, the land will have the capability to be used for productive community benefit without detrimental effect. Rather than identify specific land uses for consideration, the SRG developed a set of guidelines to assess appropriate final land use options. In Guiding Principle 9a it states that "the group believes the choice of future land use should consider:

- a range of land uses including rural or industrial uses,
- the existing natural and heritage values of the area,
- the existing surrounding land uses, and
- the needs of Pinjarra and the broader Peel Region.

This recommendation is consistent with Alcoa's commitment to demonstrate a range of possible land use options for the residue deposits. In 1994, a section of closed drying area at Pinjarra Refinery was established to demonstrate a range of land uses for the Western Australian residue areas. These land use options included 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 demonstration area. The results are described in detail in a number of annual reports and triennial reports to the DER.

Sheep and cattle have also been grazed on pastures on the demonstration area, and blood and tissue samples monitored routinely to identify any effects on animal health. 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 result in the development of guidelines for establishing a sustainable ecosystem on RSAs, both under operating and closed conditions. 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.

At Kwinana Refinery, a motor sports complex has been developed on a section of land previously used for residue storage and the requirement for that site is that closed residue areas are suitable for light industrial use.

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

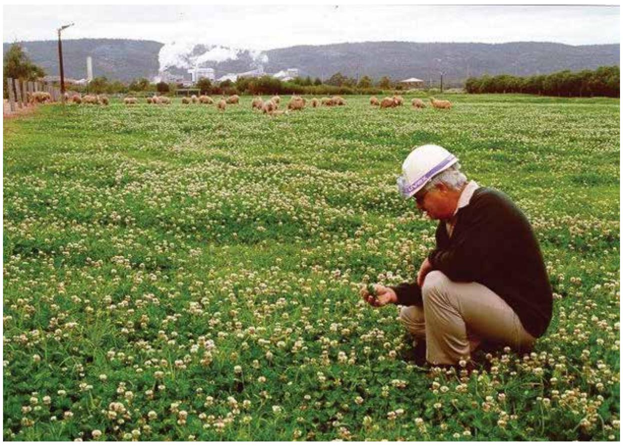
 

Plate 9-1: Agricultural land uses demonstrated at Pinjarra residue area.

significant erosion of the embankment surface under wet 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. Also, 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 that 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 Pinjarra SRG LTRMS developed a number of Guiding Principles. Those related to closure are presented below, together with Alcoa's response.

Guiding Principle: 9a) Closure – Final Land Use

After closure and rehabilitation of the refinery and residue area, the land should have the capability to be used for productive community benefit without detrimental effect. The SRG believes the choice of future land use should consider:

- *a range of land uses including rural or industrial uses,*
- *existing natural and heritage values of the area,*
- *existing surrounding land uses, and*
- *needs of Pinjarra and the broader Peel region.*

Alcoa's Response

Alcoa accepts and agrees with this Principle.

Guiding Principle: 9b) Closure – Long Term Responsibility

The ultimate responsibility for enforcement of compliance with closure management requirements lies with the state government and shall be documented in an agreement with Alcoa. The community and local government shall be involved in developing the closure strategy.

Adequate financial provisions shall be made so that the State, local community and the Shire of Murray are not left with a legacy of adverse impacts.

Alcoa's Response

Alcoa will abide by all government requirements that apply to closure funding and ensure that adequate provision is made so that there is no liability is left to the State.

Guiding Principle: 9c) Closure – Leachate Treatment

Alcoa to identify new options for leachate treatment onsite to minimise environmental risk post-closure.

Alcoa's Response

Specific leachate treatment options will be identified closer to closure. Given the rapid developments in new technology, it would be premature to identify options so far out from closure.

10 Stakeholder Reference Group Guiding Principles

10.1 Summary of Guiding Principles and Alcoa's Response

The Pinjarra 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 on residue management and planning issues, enabling them to develop well-informed Guiding Principles for consideration by Alcoa.

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 SRGs.

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

Guiding Principle	Alcoa's Response
1 DUST	
a) Control and Improvement The SRG acknowledges that dust control at Pinjarra residue has significantly improved since the last LTRMS. Alcoa to maintain the current dust control measures and seek to research and implement improved methods of control, where possible.	Alcoa is committed to maintaining its current dust control measures and seeking opportunities to improve the implementation of these measures. In addition we will continue to evaluate new dust control measures as they become available.
b) Reporting of Results The SRG request dust monitoring results presented to the CCN include assessments against the internal targets, and that any changes to dust monitoring programs are discussed with, or presented to, the CCN.	Alcoa accepts and agrees with this principle.
2 RESIDUE REUSE	
a) Priority Alcoa to continue actively pursuing alternative uses of residue. Initial emphasis is to be placed on residue sand.	Alcoa accepts and agrees with this principle.
b) Reporting Alcoa to report to the CCN annually on the status of research into residue re-use, including the status of any approvals required for its use.	Alcoa accepts and agrees with this principle.

Guiding Principle	Alcoa's Response
3 ODOUR	
a) Significance The SRG acknowledges that odour from residue is not currently considered a major issue for the community. However odour impacts of an expanded residue footprint, including wet lake relocations, should be considered.	Odour impacts will be addressed in environmental and planning approval applications, as required.
b) Control and Improvement Pinjarra Refinery to implement, where possible, any odour reduction strategies identified as part of Alcoa's broader research programs.	Where opportunities for odour reduction from residue are identified as part of Alcoa's broader research programs, Pinjarra Refinery will assess these for their applicability, effectiveness, cost and benefit to its operations. Appropriate long term strategies for the implementation of odour reduction opportunities will be developed.
4 GROUNDWATER	
a) Monitoring and Response Alcoa will continue to monitor groundwater quality around the residue area to identify seepage and leaks from the residue areas. Where leakage is identified, Alcoa to commit to timely action to prevent migration of contamination from the footprint, where possible.	Alcoa will continue to monitor groundwater quality around the residue area to identify any potential contamination issues. Where issues are identified, these will be investigated and appropriate management strategies developed to minimise their impact on the environment and prevent any impact on surrounding land/water users. As many of the monitoring bores are on the external perimeters of the residue area, it is often not possible to detect contamination until it reaches the external perimeter of the residue area. Monitoring results and progress on management strategies are reported to the DER annually in the Review of Groundwater and Surface Water Management report.
b) ROWS Remediation The SRG notes the remediation strategy in place to address identified contamination under the ROWS pond (RSA7). The SRG recommends the ROWS pond be considered as the priority over the Water Storage Reservoir for the next wet lake conversion, to allow contamination issues to be resolved.	Currently the ROWS pond conversion is planned as the next wet lake conversion. However this is dependent on a number of factors including funding and the ability to obtain the necessary approvals in the required timeframe (rezoning, and environmental approvals).
c) Integrity of the Sealed System and Liquor Containment Construction of all future RSAs at Pinjarra Refinery to be conducted in a manner that ensures safe and secure storage of residue and does not compromise ground water or surface water resources or restrict others' use.	Alcoa accepts and agrees with this principle. The current construction method is designed to achieve this outcome.
5 WATER USE	
a) Conservation Alcoa to continue to conserve water through reuse and reduction initiatives, identification of alternative sources and commitment to their use.	Alcoa accepts and agrees with this principle.
b) Regional Water Requirements The SRG encourages Alcoa, where practicable, to maximise the broader regional benefit of any future infrastructure projects.	Alcoa accepts and agrees with this principle. We will cooperate with government initiatives for economic reuse of alternative water resources.

Guiding Principle	Alcoa's Response
6 OXALATE	
The SRG notes that there is a commitment to recover all oxalate from residue storage ponds, and that the preferred method of destruction of the stored oxalate is via bi-ox, rather than via the oxalate kiln.	Alcoa is committed to recovering stored oxalate from the residue area. Oxalate stored at residue is intended to be destroyed via the biological oxidation facility; however, the continued operation of the oxalate kiln is required to treat ongoing oxalate production.
7 REHABILITATION	
a) Integration with Surrounding Environment Alcoa aims its residue area rehabilitation research at producing healthy sustainable ecosystems that can provide habitats for native Western Australian fauna. Rehabilitated residue to be integrated with surrounding vegetation and local wetlands and creeks. The value of providing an east-west vegetation corridor should be considered in preparation for closure, using the rehabilitated external residue area embankments.	Alcoa accepts and agrees with this principle. Integration of the residue area into the local environment will not be possible until operations cease. However, Alcoa will take measures to ensure that the revegetated embankments will be readily integrated into the local environment at this time.
b) Fauna Monitoring Fauna in rehabilitated residue embankments and surrounding vegetation and wetlands should be monitored to determine the effectiveness of rehabilitation.	Alcoa accepts and agrees with this principle.
8 VISUAL AMENITY	
a) Reporting and Review The SRG supports the implementation and ongoing review and update of the Visual Amenity Plan. The SRG requests any updates to the Plan be reviewed by, or discussed with, the CCN and an annual report on the implementation of the plan is provided to the CCN. The SRG notes that the residue area is more visible from locations at a greater distance and height than the major access routes identified in the Visual Amenity Plan. Although screening from these vantage points is not necessarily possible, the visual amenity impact from other locations should be noted.	Alcoa accepts and agrees with this principle.
b) Definition of Buffer The SRG notes that the purpose of any 'buffer' around the residue area needs to be well understood. There is a perception among some that the sole purpose of a 'buffer' is for planting trees. While visual amenity plantings should be a key component of compatible land use, the SRG notes this is not the sole purpose of a buffer.	Alcoa accepts and agrees with this principle.
c) Revegetation Screening Alcoa to identify proactive opportunities to enhance and improve visual amenity through revegetation screening. e.g. Between the residue area and Fairbridge e.g. Between the residue area and South West Highway.	Alcoa accepts and agrees with this principle. Alcoa has a WA-wide visual amenity lead team that meets regularly to review planning and progress with visual amenity plantings. The identified opportunities will be included in the Pinjarra Visual Amenity Plan.
d) Amend Shape of Residue Storage Areas Alcoa to investigate opportunities to amend the rectilinear form of RSAs to make them resemble a 'rolling hill' rather than the current rectangular style landform.	Alcoa will consider this suggestion during the design phase of future embankment lifts. It should be noted that changing the shape of the residue areas can introduce significant additional cost into the operations. Our preference is to use shrub and tree plantings to break up the linear profile of the residue areas. The slope of the outer embankments is also reduced to 1:6 to provide more natural profile for the areas. The effectiveness of this approach is well demonstrated on the eastern side of the Kwinana residue area, adjacent to the Kwinana Freeway.

<table>
<tr><th>Guiding Principle</th><th>Alcoa’s Response</th></tr>
<tr><td colspan="2">9 CLOSURE</td></tr>
<tr><td>a) Final Land Use
After closure and rehabilitation of the refinery and residue area, the land should have the capability to be used for productive community benefit without detrimental effect.

The SRG believes the choice of future land use should consider:
• a range of land uses including rural or industrial uses,
• existing natural and heritage values of the area,
• existing surrounding land uses, and
• needs of Pinjarra and the broader Peel region.</td><td>Alcoa accepts and agrees with this principle.</td></tr>
<tr><td>b) Long Term Responsibility
The ultimate responsibility for enforcement of compliance with closure management requirements lies with the State government and shall be documented in an agreement with Alcoa. The community and local government shall be involved in developing the closure strategy.

Adequate financial provisions shall be made so that the State, local community and the Shire of Murray are not left with a legacy of adverse impacts.</td><td>Alcoa will abide by all government requirements that apply to closure funding and ensure that adequate provision is made so that there is no liability left to the State.</td></tr>
<tr><td>c) Leachate Treatment
Alcoa to identify new options for leachate treatment onsite to minimise environmental risk post-closure.</td><td>Specific leachate treatment options will be identified closer to closure. Given the rapid developments in new technology, it would be premature to identify options so far out from closure.</td></tr>
</table>

Guiding Principle	Alcoa's Response
10 FOOTPRINT DEVELOPMENT (5-9 years)	
The SRG encourages Alcoa to convert the ROWS pond prior to additional greenfield developments.	Alcoa will consider this suggestion when updating the residue master plan. The current master plan flags the possible construction of a small (20 Ha) green-fields RSA in the north east corner of the existing residue area (east of RSA10) as the earliest opportunity to reduce the current drying area deficit. Maintaining adequate drying area is critical to the long-term stability of the residue area.
11 ROWS AND WSR LOCATIONS	
The SRG notes the strategy for locating wet lakes to the west of the current residue area is designed to minimise the overall impact on the community from residue infrastructure, as it allows new RSAs to be developed further from the existing community. The Department of Planning, Department of Environment Regulation and the Shire of Murray note that further detailed assessments or approvals are required.	Alcoa accepts and agrees with this principle.
12 FOOTPRINT DEVELOPMENT - LIFE-OF-MINE (2045)	
a) The SRG notes the basis for developing new RSAs to the North and East of the stack is to maximise separation of these areas from the majority of existing neighbours, and that Alcoa's current strategy is to maintain a 2 km separation from current residences in Carcoola/North Pinjarra and a reasonable separation from the Fairbridge Village settlement and cemetery. The SRG supports the logic of building the stack to the North first, and then to the East, to allow cut from the East to be used to develop the Northern footprint. Dept of Planning, DER and Shire of Murray note that further necessary assessments or approvals are required.	Alcoa accepts and agrees with this principle. The final development strategy will be subject to required approvals and a detailed assessment of the best overall option at the time the individual RSA development is required.
b) The SRG agrees it is desirable to present the life-of-mine footprint (2045) based on current technology and assumed production rates to provide certainty to other stakeholders. The SRG recommends that the proposed life of mine footprint be included in both regional and local strategic plans for the area to inform stakeholders of Alcoa's future plans. The SRG recognises that rezoning will also be required to allow this land use.	Alcoa accepts and agrees with this principle. As discussed during the LTRMS stakeholder engagement meetings, 2045 is the life of the current lease, but there are further provisions for the lease renewal which would extend the life of mine. Were these extensions to be granted, the life of mine footprint options would require further review.
c) Footprint Limitations The SRG notes that Alcoa will need to consider any strategic mineral resource areas and associated buffers in development of the final footprint.	Alcoa accepts and agrees with this principle.

Guiding Principle	Alcoa's Response
13 COMPATIBLE LAND USE PLANNING AROUND ALCOA'S OPERATIONS	
The SRG encourages Alcoa to continue working with relevant Local and State government authorities to ensure future land use development of surrounding properties are compatible with their current and planned operations.	Alcoa accepts and agrees with this principle.
14 HEIGHT	
The SRG recognises that the life of mine footprint is based on stack heights of between 60 and 80m above ground level.	Alcoa accepts and agrees with this principle.
15 FOOTPRINT REDUCTION OPPORTUNITIES	
The SRG requests Alcoa works towards implementing processes that will enable a reduction in the drying area required for Pinjarra's residue operations. The SRG notes that Alcoa is currently investigating the application of residue filtration technology. The SRG supports active consideration of implementing this technology. Progress in this evaluation should be reported to the CCN on a regular basis via the LTRMS update.	Alcoa accepts and agrees with this principle. Pinjarra Refinery is currently investigating new technologies for additional residue storage, including residue filtration. Final adoption of the next residue storage technology will include a number of factors, including cost effectiveness.
16 REPORTING ON THE PROGRESS OF GUIDING PRINCIPLES	
Alcoa to report annually to the CCN on its progress against the "Guiding Principles" developed by the 2016 Pinjarra LTRMS SRG.	Alcoa accepts and agrees with this principle.

11 Glossary

CCN	Community Consultative Network
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Environment and Conservation (now the Department of Environment Regulation)
DER	Department of Environmental Regulation
DIA	Department of Indigenous Affairs
DoW	Department of Water
EIP	Environmental Improvement Plan
GLC	Ground Level Concentration
HDPE	High Density Polyethylene
Hi-Vol	High Volume Air Sampler
HRA	Health Risk Assessment
LTRMS	Long Term Residue Management Strategy
Mtpa	Million Tonnes Per Annum
NEPM	National Environment Protection Measures
NORM	Naturally Occurring Radioactive Material
$PM^{2.5}$	Particulate Matter less than 2.5 µm in diameter
PM^{10}	Particulate Matter less than 10 µm in diameter
PVC	Polyvinyl Chloride
ROCP	Runoff Collection Pond
ROWS	Run Off Water Storage
RPLG	Residue Planning Liaison Group
RSA	Residue Storage Area
SRG	Stakeholder Reference Group
TEOMs	Tapered Element Oscillating Microbalances
tpd	Tonnes Per Day
TSP	Total Suspended Particulate
VOC	Volatile Organic Compound
VWP	Vibrating Wire Piezometer

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