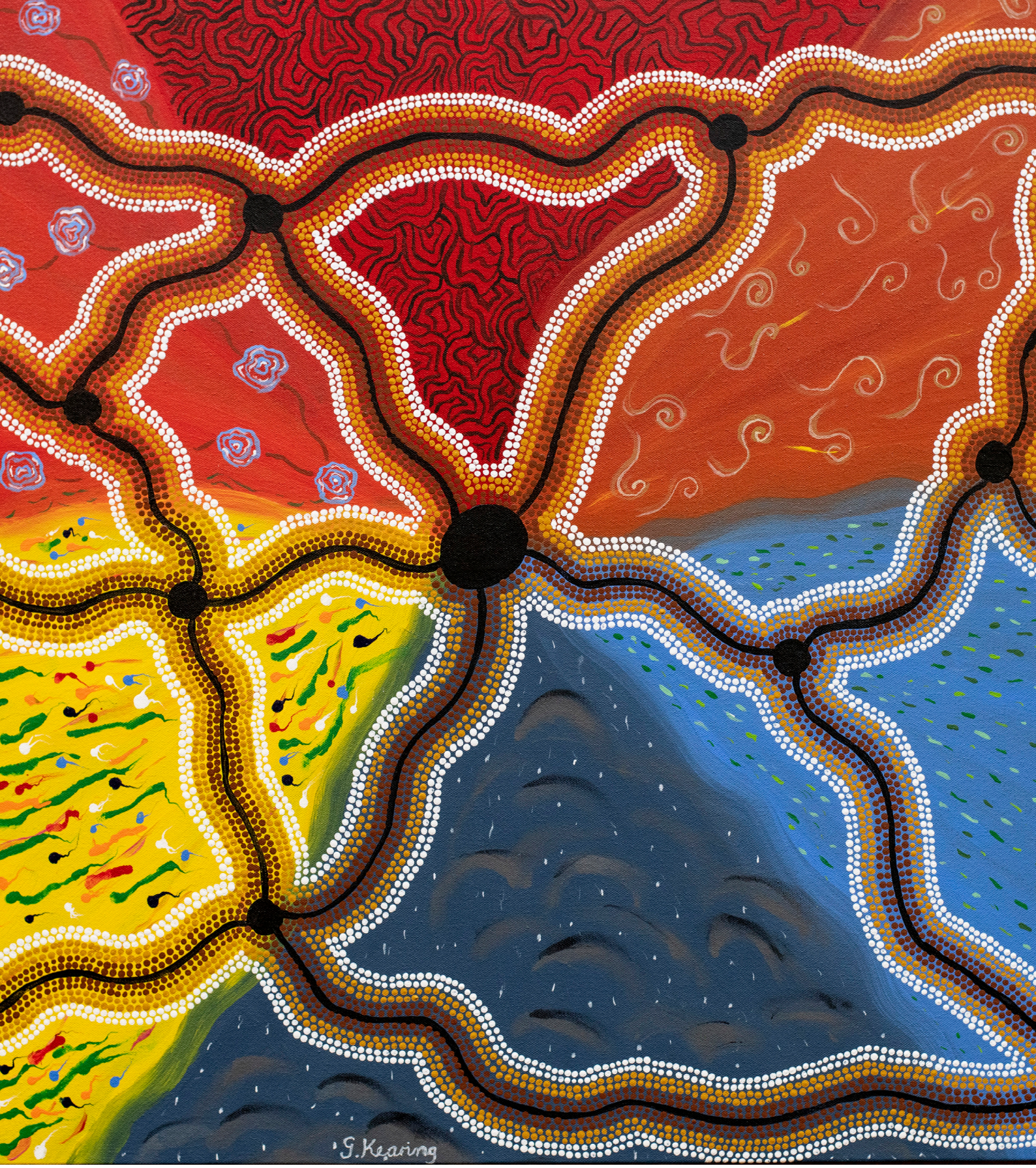
Alcoa

2020

Kwinana Alumina Refinery

Long Term Residue Management Strategy (LTRMS)



Colours of the Seasons by Gloria Kearing

Alcoa acknowledges the Traditional Owners of the lands where we operate and pays respects to their elders, past, present and emerging.

Long Term Residue Management Strategy (LTRMS)

Kwinana Alumina Refinery

Alcoa

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Executive Summary

Introduction

Alcoa's global operations represent one of the world's largest integrated bauxite mining, alumina refining and aluminium smelting systems. Alcoa's Kwinana Alumina Refinery situated 40 kilometres south of Perth in the Kwinana Industrial Area is part of Alcoa's Western Australian Mining and Refinery operations.

The Kwinana refinery which has been operating since 1963 produces smelter grade alumina, used to produce aluminium, and a variety of specialty non-metallurgical aluminas. Alumina produced at the Kwinana refinery is shipped from the Kwinana shipping terminal and is exported to overseas markets or to Alcoa's Portland Aluminium Smelter in Victoria.

Bauxite is supplied by rail to the refinery from Alcoa's Huntly Bauxite Mine. It requires approximately three tonnes of bauxite to produce one tonne of alumina. The material remaining after alumina has been extracted from the bauxite ore is commonly termed 'bauxite residue'.

All of Alcoa's Western Australian mining and refining operations have earned certifications from the Aluminium Stewardship Initiative (ASI) and ISO14001:2015, which is validation of our commitment to responsible and sustainable production and working with stakeholders to deliver long-term value.

The Kwinana Alumina Refinery Long Term Residue Management Strategy (LTRMS) was developed in response to a voluntary commitment to prepare long term strategy and closure management plans for bauxite residue deposits. This LTRMS represents the fourth published strategy following the third review in 2012 and a partial review in 2013.

A reference group of key stakeholders including community members, local and state government and Alcoa representatives actively participated in the review of the strategy in 2019. This document covers context and information presented to and outcomes from, the Stakeholder Reference Group (SRG) process.

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

Purpose of LTRMS

The LTRMS document is designed to inform local and state governments and the wider community of Alcoa's long-term management strategies for residue management. It outlines the Kwinana refinery's current short-term (2020-2024), mid-term (2024-2034) and life-of-mine (2045) management strategies for bauxite residue, including issues such as:

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

The LTRMS also addresses current plans for closure of the residue storage area (RSA), future land use options for the RSA 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 practices. These issues are managed via the Environmental Management System (EMS) and Environmental Improvement Plan (EIP) processes for the Kwinana refinery.

This report is designed to enable stakeholders to review both the longer-term strategy and those projects on the immediate planning horizon. The LTRMS is anticipated to address the key information requirements of the planning and approval mechanisms for the next 5-7 year period so that endorsement of this document by the Residue Planning Liaison Group (RPLG) and Ministers for State Development and Environment supports streamlined approvals processes. The outcomes of this LTRMS will also be incorporated into the ongoing operational planning processes for the Kwinana residue area.

Consultation and key issues

The contents of this document are based on issues and information discussed during consultation with a SRG comprised of members of the community, Local and State Government Departments and Alcoa. The purpose of consulting broadly with the community and government stakeholders in the development of this LTRMS was to:

- have stakeholders engaged 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 are transparent and documented.

A summary of the SRG's deliberations has been provided in the form of 21 Guiding Principles to Alcoa for consideration in the development of the LTRMS. These were developed for environmental and social issues considered particularly significant by the group and include:

- dust management;
- waste management;
- residue area development;
- water;
- residue reuse; and
- rehabilitation and closure.

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.

Management of Residue Facilities

Alcoa has a Global Impoundment Policy which provides direction for the management and governance of our residue storage areas in accordance with Regulatory requirements, Industry Guidelines such as the International Council on Mining and Metals (ICMM) supported Global Industry Standard on Tailings Management. These industry guidelines include design criteria for earthquake risk, long term stability and management of storm events.

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 prior to the commencement of construction and forms the basis for government agency review and environmental approval.

As part of the governance processes in place to manage safety, residue areas are subject to independent inspection processes and periodic regulatory review to ensure that they are being constructed and operated correctly.

The main concern relating to the physical structure of the residue area 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.

Alcoa is aligned with other global entities who seek to maintain appropriate buffers around residue areas, by supporting compatible land use planning to reduce populations at risk should a low likelihood, high consequence embankment failure / worst case scenario ever eventuate.

Together with best practice environmental controls, compatible land use planning is considered necessary to prevent conflict from urban encroachment on industrial operations. Compatible development does not seek to quarantine land from development, but to ensure the land use(s) and intensity of activities thereon, remains appropriate to operational risks, preserving and enhancing the orderly and proper planning of the locality.

Residue Footprint Options

Alcoa's options for residue storage area expansion at the Kwinana refinery is affected by land availability and the need for adequate separation distances which consider impoundment safety, environmental and amenity requirements.

The area to the east of the existing residue storage area is currently subject to Improvement Plan 47 – Mandogalup (gazetted April 2019) process which seeks to establish the strategic planning and development intent within the IP47 area, including the preparation of an improvement scheme.

The Kwinana residue footprint master planning forecasts expansion westwards, however this is constrained by industrial development in Latitude 32 and the Flinders Precinct and limited land options around the existing residue facility. Urban areas and service infrastructure affect land options to the north and south for the existing facility.

Alcoa's operations are best supported by planning outcomes which seek to minimise the potential for land use conflicts.

Alcoa considers it important to maintain an industrial interface consistent with the State's Planning Policy framework and established buffers including: the 1km Kwinana Air Quality buffer zone; and 1 – 1.5km transitional zone.

In addition to land availability, the volume and rate of residue produced, the stack design, drying method and open surface area required for the drying cycle determines the final footprint of the residue area. The viability of alternative uses for residue will also affect the final volume of residue requiring storage.

In 2017 Alcoa commissioned residue filtration technology at Kwinana which supports optimal use of the land available for bauxite residue storage. Residue filtration uses a plate and frame pressure filtration process to produce a dry residue filter cake by filtering the residue mud slurry through a filter cloth. The filtration process achieves a residue moisture content that would typically take approximately 100 days to achieve by traditional solar drying effectively slowing the rate of expansion of the residue footprint to maintain adequate surface area for traditional solar drying processes. The cake has a moisture content low enough to allow for conveying and stacking of the residue material. Filtration processes have also recently been introduced to residue operations at Alcoa's Pinjarra Alumina Refinery (Stage 1).

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

- a lower potential risk of groundwater contamination from residue areas;
- a reduction in contaminated run-off water requiring treatment and discharge after refinery closure;
- less surface area requiring dust management and rehabilitation;
- better definition of land separation requirements between residue and neighbouring properties; and
- reduction in the overall land area which may have long term planning constraints.

Other critical factors that need to be considered in stack design include structural stability, visual amenity and dust potential.

To minimise the footprint, the design of the residue stack is optimised wherever possible to ensure the most efficient use of land. Residue filtration reduces the active solar drying area requirements for residue mud and related rate of footprint development. Other opportunities to minimise the final volume of the footprint are sought through research into commercially viable residue reuse options.

Constraints on Forward Planning

Alcoa periodically updates the comprehensive residue management master planning processes for the short-term (2020-2024), medium term (2024-2034), and life of the current mining lease (life-of-mine, 2045). These planning processes consider the guidance provided through the LTRMS SRG process.

For the purposes of this planning process, the life-of-mine is considered the life of the current bauxite mining lease 1SA (2045). However, given the capacity of the mine and renewal options on the bauxite lease, the exact date of closure and volume of residue requiring storage remains uncertain.

Despite the level of effort which goes into forward planning, shifts in direction are occasionally required as a result of a range of factors which are outlined in Section 8.2. The plans presented in this LTRMS are therefore subject to change. The periodic review process for the LTRMS is designed to allow these changes and their impact on long term planning for the residue storage area (RSA) to be reviewed and discussed with community and government stakeholders. If a significant change will impact the short-term plan presented in this document, additional consultation may be required.

Short-Term Construction Strategy

Key issues to be managed within the short-term (2020-2024) are to consolidate the existing residue area to make more efficient use of the drying area. The short-term residue construction activities are outlined in Section 8.7.

Mid-Term Construction Strategy

Alcoa's focus for the mid-term strategy (2024-2034) is maintaining the residue storage and drying capacity to meet the requirements of the refinery and is outlined in Section 8.6.

Life-of-Mine Strategy

Alcoa currently has sufficient appropriately zoned land to provide residue area for the life of the refinery, at current planned production rates, with assumed capacity of the bauxite residue filtration and the known bauxite reserve within Mineral Lease 1SA.

Currently there are areas utilised for other processes that may be used for residue storage in future. Projects to reclaim these areas for residue storage use are outlined in Section 8.5.

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. Residue closure and rehabilitation is discussed in Section 9.

Engagement and Review Schedule

The LTRMS will be periodically reviewed and as determined by strategic need. The process of future stakeholder consultation is anticipated to be similar to that undertaken in this review.

Concluding Remarks

The development of this LTRMS has been a constructive means of engaging the community. Alcoa is very appreciative of the Kwinana LTRMS SRG members who provided a considerable amount of personal time and commitment in working with Alcoa during 2019 and beyond to produce this important Strategy for the Kwinana Refinery.

Figure A: Kwinana Refinery Residue Filtration Facility

Introduction 1

1.1 Background and Site Overview

In Western Australia, Alcoa owns and operates alumina refineries at Kwinana, Pinjarra and Wagerup, with a combined capacity of approximately nine million tonnes per annum (mtpa), equivalent to around 45% of Australian production and more than 7% of world demand. The company also operates bauxite mines at Huntly and Willowdale in the Darling Range, south of Perth. A map of Alcoa's operations in Western Australia is provided in Figure 1-1.

The Kwinana refinery has a capacity of approximately 2.2 million tonnes of alumina per year. It produces smelter grade alumina, used to produce aluminium, and a variety of specialty non-metallurgical aluminas, which have a wide range of industrial and manufacturing applications. Alumina produced at the Kwinana refinery is shipped from the Kwinana shipping terminal and is exported to overseas markets or to Alcoa's Portland Aluminium Smelter in Victoria.

Bauxite is supplied by rail to the refinery from Alcoa's Huntly Bauxite Mine. It requires approximately three tonnes of bauxite to produce one tonne of alumina. The material remaining after alumina has been extracted from the bauxite ore is commonly termed bauxite residue or simply residue.

1.2 Purpose of the Long Term Residue Management Strategy

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

A reference group of key stakeholders including community members, local and state government and Alcoa representatives, actively participated in consultation meetings during a three-month period. Most of the document's content reflects presentations to, and outcomes from, the SRG, with additional contextual information provided as required.

The LTRMS reflects current knowledge, technology and regulatory standards. The document does not provide detailed engineering information for future residue management.

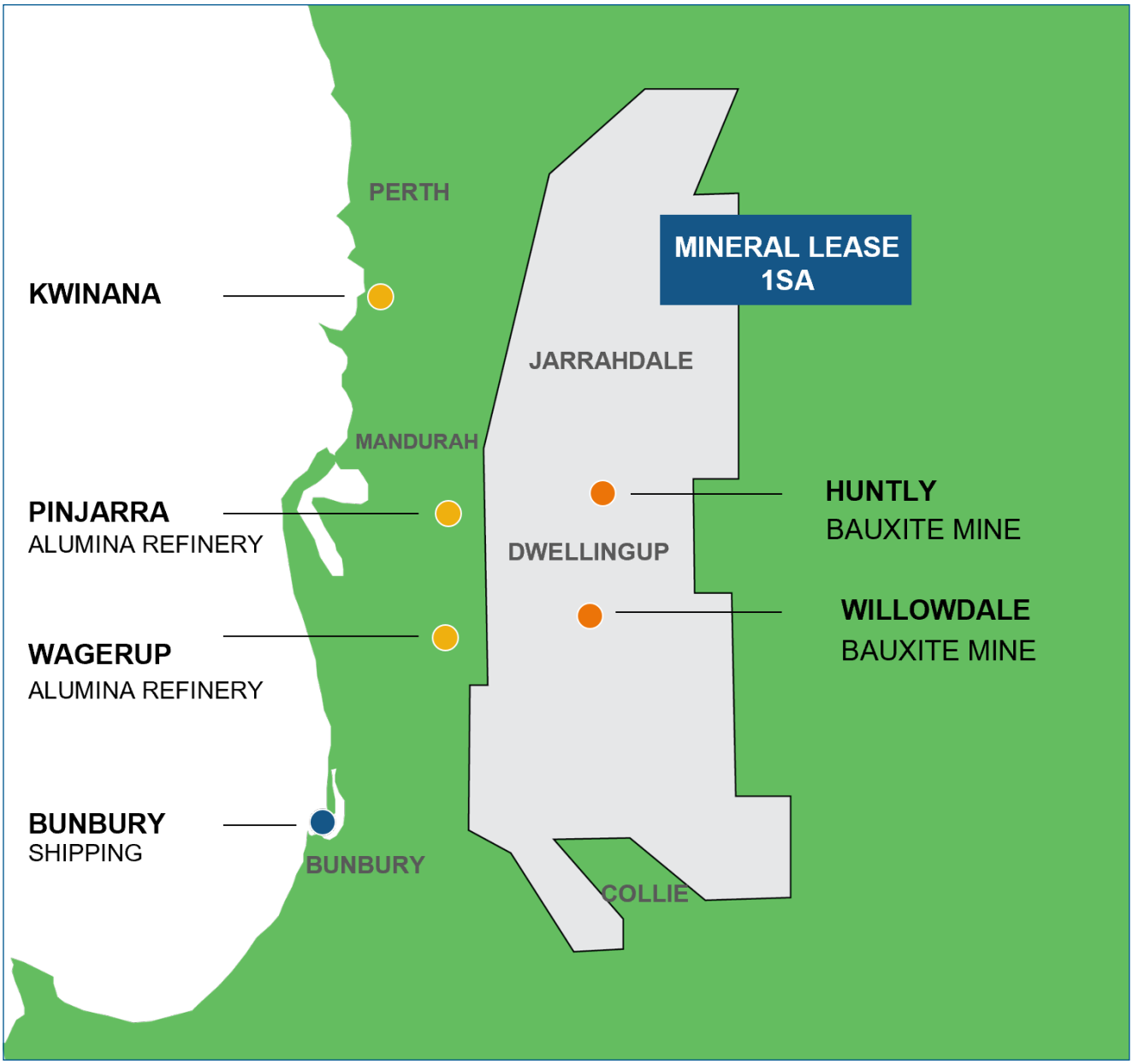

Figure 1-1: Location Map

2 Background & History of the LTRMS

Alcoa has had an active bauxite residue management program for almost 60 years in Western Australia that has focused on emissions control, improvement in engineering management practices and alternative uses for residue.

2.1 Initial LTRMS Development

As part of the 1989 Consultative Environmental Review (CER) for the Wagerup Unit Two Expansion, Alcoa agreed to develop long term and closure management plans for residue deposits in consultation with relevant State agencies.

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

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

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

In addition, the RPLG agreed on a process and schedule for review of the Wagerup LTRMS.

Alcoa voluntarily agreed to extend this process to the Pinjarra and Kwinana refineries.

In August 1995 an expansion of the Wagerup refinery was authorised by the Minister for the Environment. The Minister's statement (Number 390) set specific requirements for the Wagerup Refinery including the expectation for Alcoa to 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 Kwinana refinery, Alcoa voluntarily committed to prepare a long-term residue management strategy for the Kwinana operations.

The Kwinana refinery LTRMS was first produced in 1998 to enable Alcoa to demonstrate sound environmental management of the residue area to government and community stakeholders.

2.2 2005 LTRMS Review

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

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

2.3 2012 LTRMS Review and 2013 LTRMS Partial Review

A further review of the LTRMS commenced in 2011 and repeated the previous successful use of an SRG to obtain advice and feedback on strategy options from local community, local government and regulatory authorities.

The 2011 LTRMS SRG review addressed residue infrastructure requirements for the life of the mine (2045) the 25-year footprint requirements and the 5-7 year development plan.

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

In 2013 a partial review of the LTRMS prompted by the plan to introduce filtration technology was progressed in consultation with community and government stakeholders.

2.4 Sustainability

Across Alcoa's global operations, sustainability drives us to minimise our negative impacts and maximise our value. Our sustainability strategy supports our strategic priorities through three pillars:

- create sustainable value for the communities where we operate, with the aim to maintain our license to operate with opportunities to grow our businesses;
- enhance the value of our products through differentiation to improve our profitability; and
- minimise our environmental impacts and improving our health and safety performance to reduce our risk exposure.

Our long-term sustainability goals help guide our actions.

Alcoa's drive to apply these sustainability pillars is reflected in the emphasis of this document. The approach to residue management embraces stakeholder engagement, with local community and stakeholders directly involved in the planning process. This has ensured that the concerns and queries of the local community, local government and regulatory authorities, and Alcoa's response to these issues, are transparent and documented.

All Western Australian mining and refining operations have earned certifications from the Aluminium Stewardship Initiative (ASI) and ISO14001:2015, which is validation of our commitment to responsible and sustainable production and working with stakeholders to deliver long-term value.

2.5 Alcoa's Stakeholder Engagement Process

Alcoa recognises that talking to communities, seeking input into plans, sharing environmental performance and understanding community needs is critical to maintaining its social licence to operate. Consequently, a range of informal and formal consultation methods have been employed by Alcoa to involve and inform the community of the company's activities. The Kwinana LTRMS stakeholder consultation process is only one of Alcoa Kwinana's consultation processes.

2.5.1 Other Community Consultation

Kwinana refinery established its first Community Consultative Network (CCN) in December 1994 to engage with the community and better understand areas of concern and interest.

In 2004 the then Department of Environment (DoE) introduced a new initiative for WA industry: voluntarily adopt public Environmental Improvement Plans (EIPs). After Alcoa chose to produce an EIP for its Kwinana refinery in 2005, a decision was made to transform the CCN into an EIP Advisory Group to provide guidance in the development of Kwinana refinery's EIP.

During 2010, Kwinana refinery's EIP Advisory Group provided input and guidance during the development of the 2011 – 2013 EIP and the EIPs developed since. The current EIP covers the 2017-2021 period and the group meet quarterly.

As a member of the Kwinana Industries Council (KIC), Alcoa participates in the Kwinana Community and Industries Forum (CIF).

2.6 Kwinana LTRMS Stakeholder Reference Group

2.6.1 Formation of the Kwinana Stakeholder Reference Group

The Kwinana LTRMS SRG was formed in August 2019 and met regularly from September 2019 until November 2019 to provide input to Guiding Principles for the 2020 LTRMS. The process used to establish the SRG is outlined below.

The framework for stakeholder consultation in the LTRMS review for Kwinana refinery is presented schematically in Figure 2-1.

Landholder Representation

To ensure adequate representation by landholders on the SRG, a letter was sent to local residents in June 2019, inviting them to participate in the review of the LTRMS as a member of the SRG.

Advertisements were also placed in local papers in July 2019 inviting near neighbours, local business owners and those with a special interest in the environment to nominate.

All local residents who expressed an interest joined the group. The group formed included five community members.

Local Business and Property Developer Representation

A nomination was received and accepted from one local business. Two property development companies also nominated, and both nominations were appointed to the SRG.

Government Representation

Local and state government representation was sought and received from the City of Kwinana, City of Cockburn, Department of Jobs, Tourism, Science and Innovation, Department of Planning, Lands and Heritage and Department of Mines, Industry, Regulation and Safety.

Community and Industry Special Interest Groups

Representatives from the Friends of the Spectacles and Kwinana Industries Council nominated and were accepted.

Alcoa Representation

Alcoa was represented on the LTRMS by its Government Relations Manager, WA Residue Operations and Maintenance Manager, Residue Senior Environmental Consultant, Kwinana refinery Environmental Manager, and the Kwinana refinery Community Relations Officer.

The Global Alumina Residue Manager attended some of the meetings as an observer.

Meeting reports were produced by Residue Senior Environmental Consultant, and Kwinana refinery Community Relations Officer.

Alcoa subject matter experts attended relevant meetings to present on the various topics.

Figure 2-1: Framework for Stakeholder Reference Group Participation in LTRMS Development

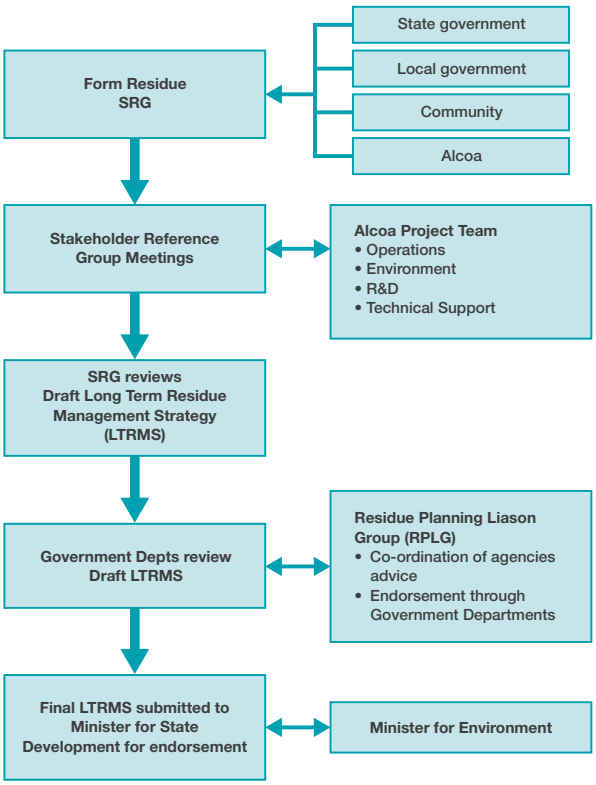

Table 2-1 Kwinana LTRMS Stakeholder Reference Group membership

AFFILIATION	NAME
Neighbours and Community Members	
Neighbour	name removed
Neighbour	name removed
Neighbour	name removed
Neighbour	Tony Hurle
Community Member	name removed
Neighbouring Businesses and Property Developers	
Italia Stone Group	Tinus Nagel
Satterley Property Group	Ray Stokes
QUBE Developers	Jackie De Meyrick
Local Government	
City of Cockburn Council	Cr Michael Separovich
City of Cockburn	Lorenzo Santoriello
City of Kwinana Council	Cr Dennis Wood
City of Kwinana	Maria Cooke
State Government	
Department of Jobs, Tourism, Science and Innovation	Phil Knight
Department of Planning, Lands and Heritage	Alice Brown
Department of Mines, Industry, Regulation and Safety	Phil Boglio
Community and Industry Special Interest Groups	
Friends of the Spectacles	Gary Allen
Kwinana Industries Council	Chris Oughton
Alcoa	
Global Residue Manager, Alumina	Paul Smithall
WA Residue Operations and Maintenance Manager	Matthew Cox
Government Affairs Manager	Scott Harper
Kwinana refinery Environmental Manager	Elizabeth Brockbank
Residue Operations Senior Environmental Consultant	Anika Wall
Kwinana refinery Community Relations Officer	Scott Hansen
Independent Facilitator	
Storybox Consulting	Liz Storr

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

An independent facilitator, Liz Storr, was appointed for the SRG. The initial meeting of the SRG involved the clarification of the group's role and operation in the LTRMS planning process. It was agreed that the responsibilities of the SRG are to:

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

Meetings were held fortnightly. Issues discussed at the SRG meetings were recorded in meeting reports. During the September to November 2019 period five meetings were held in Kwinana to address the issues raised by the SRG. Table 2-2 contains the actual meeting schedule and issues addressed by the group.

Table 2-2 LTRMS Stakeholder Reference Group Meeting Schedule

MEETING NO.	DATE	TOPICS COVERED
1	2 September 2019	Introductions LTRMS Overview Working Together Agreement Tour Kwinana refinery's Residue Area
2	23 September 2019	Future Residue Area Development Plans Environmental Management
3	14 October 2019	Residue Reuse Residue and Health Residue Area Rehabilitation, Closure and Final Land Use
4	4 November 2019	Approvals Required to Implement LTRMS Finalise Guiding Principles
5	25 November 2019	Alcoa's Response to Guiding Principles

2.6.3 Key outcomes of the Stakeholder Reference Group Process

As a result of the process undertaken 21 guiding principles were developed by the SRG covering six topics. These guiding principles were considered by Alcoa and addressed, where possible, in the Kwinana LTRMS. The complete table of guiding principles, together with Alcoa's response to them, are detailed in Section 10. The relevant guiding principles are provided in sections where the Kwinana LTRMS SRG determined that a guiding principle was required.

Alumina Refining Process

3

3.1 Overview

The Kwinana refinery produces alumina from bauxite using the Bayer Process. The process involves four main steps: digestion, clarification, precipitation and calcination. In addition, two other important activities occur on site: the generation of power and steam for the Bayer Process, and the storage of bauxite residue (the material remaining after alumina is extracted) in impoundment areas known as RSA's.

The refinery water circuit is fully contained through recycling processes, with no discharge to the environment.

3.2 Digestion

Bauxite is milled to sand size particles and hot concentrated caustic soda solution is added making a bauxite slurry. The hot caustic dissolves the available alumina within the bauxite.

3.3 Clarification

Sand and clay (red mud) are settled out leaving an alumina rich 'green' liquor. The settled-out sand and mud are washed and pumped to the residue area.

3.4 Precipitation

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

3.5 Calcination

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

3.6 Power and Steam Generation

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

3.7 Bauxite Residue and Waste

The material remaining after the alumina has been extracted from the bauxite ore is commonly termed bauxite residue. Bauxite residue is produced at a rate of approximately two dry tonnes per tonne of alumina. This material is stored at the residue areas near the refinery.

Residue consists of a coarse sand fraction (often termed red sand) and a fine silt fraction (often termed 'red mud'). The mud and sand streams are pumped together to the residue area and separated in the sand separation building located at the residue area. Approximately 55 per cent of the residue stream is sand and 45 per cent is mud. The mud density is increased at the residue area by thickening prior to its final discharge into RSAs either directly or via the residue filtration plant. The sand is used for internal construction activities at the RSA. Oxalate, another process organic by-product, is either processed or stored in storage ponds on site.

Several other facilities that support the refining operations are located in the residue area. These include ponds to cool refinery process liquor and to store rainfall run-off water from both the refinery site and residue area. The system is designed to contain the accumulated rainfall run-off up to a 1:100 wet year. Water is recycled back to the refinery via the cooling and lake water ponds. Landfill, drainage and groundwater management systems are also located in the residue area.

3.8 Refinery Water Circuit

Alcoa focuses on using water of a quality that is fit for purpose and substituting higher quality water with lower quality water where possible.

The refinery operates a closed water circuit, which is supplemented for water losses. Losses of water primarily occur as steam from the process, evaporation from water storage areas and residue surfaces, and water bound within the residue mud and sand.

Make-up water is primarily taken from licensed groundwater sources and Water Corporation supply. Onsite sources of make-up water include water contained in the caustic soda, moisture in bauxite, groundwater recovery bores and rainfall runoff. All rainfall runoff from the refinery site and residue area is captured, stored in lined ponds and recycled back into the refinery process.

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

4 Bauxite Residue Management

4.1 Overview

Early bauxite residue management processes involved the deposition of residue mud as dilute slurry into storage areas – termed wet disposal. In 1987, Kwinana refinery adopted an alternative residue mud storage technology previously termed dry stacking, hereinafter referred to as solar drying. This process involves pre-thickening the residue mud and then depositing it in layers which are dried through solar evaporation. The process is assisted by physically turning over the mud, and produces a high-density, stable stack of residue upon which the next mud layer can be placed.

Solar drying of thickened residue mud is fully operational at all three of Alcoa's Western Australian refineries, and this type of storage has been adopted by other minerals industries. The advantages of this method include:

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

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

In 2017 Alcoa commissioned Bauxite Residue Filtration technology at Kwinana which supports optimised use of the land available for residue storage. Residue Filtration uses a plate and frame pressure filtration process to produce a dry residue filter cake by filtering the residue mud slurry through a filter cloth. The filtration process achieves a residue moisture content that would typically take 100 days to achieve by traditional solar drying. By shortening the time required for solar drying the rate of expansion of the residue footprint to maintain adequate surface area for traditional solar drying processes is reduced. The cake has a moisture content low enough to allow for conveying and stacking of the residue material. Benefits from residue filtration include:

- a reduction in water usage;
- a slower rate of residue footprint expansion;
- improved residue dam constructability and stability;
- optimised use of the residue footprint; and
- a reduction in dust potential from residue storage areas.

Alcoa's second residue filtration facility has been constructed at the Pinjarra Alumina Refinery (Stage 1) and was commissioned in 2019.

Kwinana refinery operations primarily use filtration, supplemented by solar drying. Traditional wet storage and direct slurry disposal are used when periodic plant maintenance is undertaken on the equipment supporting the primary disposal systems.

Alcoa believes the bauxite reserve in Mineral Lease 1SA will sustain the company's operations for at least another 50 years. During this time, it is anticipated that alumina production will become more efficient and bauxite residue reuse options will assist in reducing the volume of residue to be stored. For the purposes of this planning process, the life-of-mine is considered the life of the current lease (2045).

However, given the capacity of the mine and renewal options on the bauxite lease, at present the exact date of closure and volume of residue requiring storage remains uncertain.

Residue area expansion is planned to the west of the current footprint within the existing residue footprint in the next five to seven years. The rate of expansion of the residue footprint will depend on the actual Kwinana alumina refinery production rates over time and the height of the stack, which is governed by a number of factors including stability and visual amenity issues. The height of the residue area will also influence the direction and timing of the footprint expansion; a higher stack allows the footprint to be contained to a smaller overall footprint.

4.2 Residue Characteristics

4.2.1 Chemical Condition

As described in Chapter 3, bauxite is crushed, ground and leached with a caustic soda solution during the alumina refining process. The remaining residue consists of both solids and entrained alkaline solution. During alumina extraction, raw caustic soda solution, lime, and small quantities of chemical reagents are added. Side reactions occur which form small quantities of alkaline solids in the residue (Alcoa, 1997).

From an environmental viewpoint, the alkalinity of the bauxite residue imparted by the addition of caustic soda and lime is of most note. Typically, the solution entrained with the residue has a total alkalinity of between 20 and 30 grams per litre (g/L) expressed as sodium carbonate, and a pH of 13. Specifically, the alkalinity of the residue affects the mud drying rate and the dusting potential of the residue surface.

Alcoa developed a process to reduce the pH of the bauxite residue to around 10.5 by reacting the residue slurry with carbon dioxide. This process, termed carbonation, was implemented at Kwinana and was operational for a period prior to the introduction of residue filtration.

4.2.2 Physical Condition

Bauxite residue is composed primarily of iron and silica minerals. Residue from Darling Range bauxite is characterised by a high coarse fraction, due to silica in the bauxite. The coarse fraction can be considered as a fine to medium grained sand (greater than 150 µm) with a specific gravity of 2.9. This residue sand has proved to be an ideal material for residue storage embankment and road construction within the operation, as a free draining material suitable for surface rehabilitation, and for the construction of drainage layers at the base of the RSAs (Alcoa, 1997).

The fine fraction of the residue, commonly termed red mud, is silt to clay sized material (less than 150 µm) with a specific gravity of 3.2. The higher specific gravity of the fine fraction results from the relatively high iron content. This fine fraction settles very slowly and has little strength unless dewatered or dried. When in slurry form, the fine fraction must be contained within engineered embankments (Alcoa, 1997).

4.3 Physical Structure of Storage Areas

A schematic diagram of the traditional slurry, solar drying and filtration processes used at Alcoa's residue area is presented in Figure 4-1. Both these processes are utilised for residue storage together with deposition of slurry during equipment outages.

The fine tailings are pumped to a thickener vessel (known as the Super Thickener) where they are settled using flocculent, producing high-density underflow slurry of 40 to 50 per cent weight for weight (w/w) solids. This slurry is then pumped to the RSAs where it is placed in layers and allowed to dry through evaporation or processed through residue filtration.

To assist the natural drying process of unfiltered residue, the surface of the RSAs is mechanically turned over by bulldozers and amphirols to enhance solar drying. The final tailings has a dry density and moisture content lower than that of un-thickened tailings when Alcoa used earlier wet disposal methods. Drainage and evaporation increases the thickened tailings dry density over time.

The filter cake produced from residue filtration has approximately the same moisture content of solar and mechanically dried tailings, thus reducing the need for evaporative drying.

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

Safety and Environmental Concerns

The main concern relating to the physical residue embankment structure of the residue storage area is the potential for embankment failure, which could potentially result in the release of residue slurry or liquor into the surrounding environment. To mitigate this risk, RSA remove water via decants and underdrains to maximise the stability of the structures. Also, of possible concern are the more gradual processes of wind and water erosion to the residue storage area, particularly on the sloped embankments of the bauxite residue deposits.

4.3.1 Current Management Strategies

From the commencement of Alcoa's operations in Western Australia, RSAs have been designed and constructed in accordance with high engineering standards. Prior to the introduction of solar drying of thickened residue mud, residue embankments for slurry deposition 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 solar drying of the thickened residue mud 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 mandated Alcoa and international standards to accommodate both static and earthquake loadings. In addition, the structural integrity of water storage ponds and RSA embankments are inspected annually by Alcoa and qualified independent third-party engineering consultants. Periodically the regulator also inspects the facilities. These residue storage area design standards are implemented to ensure the stability of the residue storage areas and to minimise any potential safety and environmental risks.

In response to global events related to the catastrophic loss of tailings containment (Brumadinho January 2019), Alcoa undertook a complete review of its Impoundments (bauxite residue, tailings and water dams) design standards and governance criteria. The review benchmarked International Tailings Standards. This ensured auditable processes were in place to monitor operating performance.

Alcoa is aligned with other global entities who seek to maintain appropriate buffers around residue areas, by supporting compatible land use planning to reduce populations at risk should a low likelihood, high consequence embankment failure/worst case scenario ever eventuate.

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 drying areas increases over time, perimeter embankments progressively move inwards, and the net available drying area reduces. Therefore, to maintain the minimum drying area required to dry mud it is necessary to periodically construct new drying areas.

Figure 4-2 illustrates the process of developing the overall stack. Area A would need to be built and filled before you can start to build B.

The filtered mud whilst mechanically placed is layered and stacked in a similar manner. The slope profiles may differ depending on the residue material, i.e. filtered mud, mud or sand.

4.5 Construction of New Residue Facilities

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

Alcoa has a Global Impoundment Policy which provides direction for the management and governance of our residue storage areas in accordance with regulatory requirements, industry guidelines such as the International Council on Mining and Metals (ICMM) supported Global Industry Standard on Tailings Management. Alcoa is a member of the International Council on Mining and Metals (ICMM) and has committed to implement the Global Industry Standard on Tailings Management (GISTM).

The RSAs are designed in accordance with mandated Alcoa Global Impoundment Standards which reference 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 impoundment standard 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:

- suitably constructed low permeability base and embankment seal utilising composite liner systems;
- 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;
- 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 for solar dried; bauxite residue is completed using an upstream embankment construction 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 engineering stability models that consider a range of loadings.

Residue storage areas are subject to annual inspection by an independent engineering consultant and regulatory review to ensure that they are being constructed, maintained and operated as designed. If the independent consultant recommends further stability investigations to Alcoa, stability assessments are undertaken using a cone penetrometer testing (CPT) which gives a profile of material strength by measuring the resistance generated by forcing a probe through the residue stack. The results are used to generate a Factor of Safety (FoS) for the stack configuration. If stability issues are suspected, further detailed geotechnical studies are carried out and corrective actions are implemented to ensure ongoing adequate stability.

4.5.1 Borrow Materials

The construction of future RSAs requires mining of low permeability clay to line the base of the residue deposit. This clay is generally mined from available deposits on Alcoa-owned property south of the current residue footprint and borrow areas are rehabilitated when the resource is exhausted.

Modern synthetic clay composite liner materials are now available provide an alternative to traditional clay systems.

4.6 Bauxite Residue Research and Development Activities

4.6.1 Overview

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

4.6.2 Reuse Strategies

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 commercialised for use in road construction, industrial land development and top dressing of turf for recreational uses.

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 specific applications, although a number of applications have been trialled where it has proven to perform equal to or better than virgin sand materials. However, 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. These trials included topdressing of turf for recreational uses, road construction, and industrial land development. Red Sand™ is well structured and has improved retention properties compared to local sands. Red Sand™ has also been assessed as a growth medium for turf production, as a topdressing 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 Alumina 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 Kwinana refinery with the sand produced being used to top-dress the Alcoa Social Club oval and in a series of trials with various golf clubs, and an industrial land development trial in conjunction with the Western Australian land authority.

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

- A radiological assessment which has resulted in approval by the Radiological Council of Australia for road construction and top dressing.
- 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.
- 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.
- 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 then Department of Environment Regulation (now DWER) released guidelines for the use of waste derived materials (WDM). These guidelines provided 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 DWER. Alcoa prepared an application for Red Sand™, which also required review by an independent DWER accredited contaminated sites auditor prior to submission, as per the WDM guideline. The auditor report was supportive of Red Sand™ being used for the proposed applications (road construction, industrial land development, and topdressing recreational ovals). The final submission was made in early June 2016. Unfortunately, DWER have since removed the WDM administrative framework and responded to our application in July 2017 specifying that they would not make a formal determination on our application.

In October 2018 the DWER released a factsheet and (DWER Factsheet) to provide guidance on assessing whether material is waste within the meaning of the EP Act and WARR Act. It remains the responsibility of the person in possession of the material to determine whether their material is a waste, but the factsheet outlines the process that DWER would follow to make a determination when performing their function. Alcoa is considering the future use and commercialisation of Red Sand™ within this context.

Alcoa has also led the implementation of leaching test methods developed in the European Union by the ECN into Western Australia. 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 have been developed, applied and validated in WA.

4.6.3 Residue Reuse Guiding Principles and Alcoa's Response

In response to the information provided, the Kwinana LTRMS SRG developed three guiding principles related to alternate uses for residue. These are presented below, together with Alcoa's response.

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	Residue Reuse	
12	Alcoa to continue to actively pursue safe alternative uses of residue.	Alcoa will continue to pursue safe, environmentally sustainable and viable alternative uses of residue. Each potential use will be assessed for feasibility on a case-by-case basis.
13	Alcoa to provide updates to stakeholders regarding the status of residue re-use projects, more regularly when progress made is material.	Alcoa will provide updates to stakeholders through the existing stakeholder engagement processes.
14	Alcoa to minimise impacts of residue reuse infrastructure and processing on surrounding areas, environment and neighbouring communities, including waste management, transport, noise, dust, odour; in accordance with approved licencing conditions.	Alcoa is currently studying the feasibility of the commercialisation of the Red Sand™ (washed and carbonated bauxite residue sand) product. If the production of the Red Sand™ is deemed feasible, environmental and social considerations will be factored in to the Red Sand™ project.

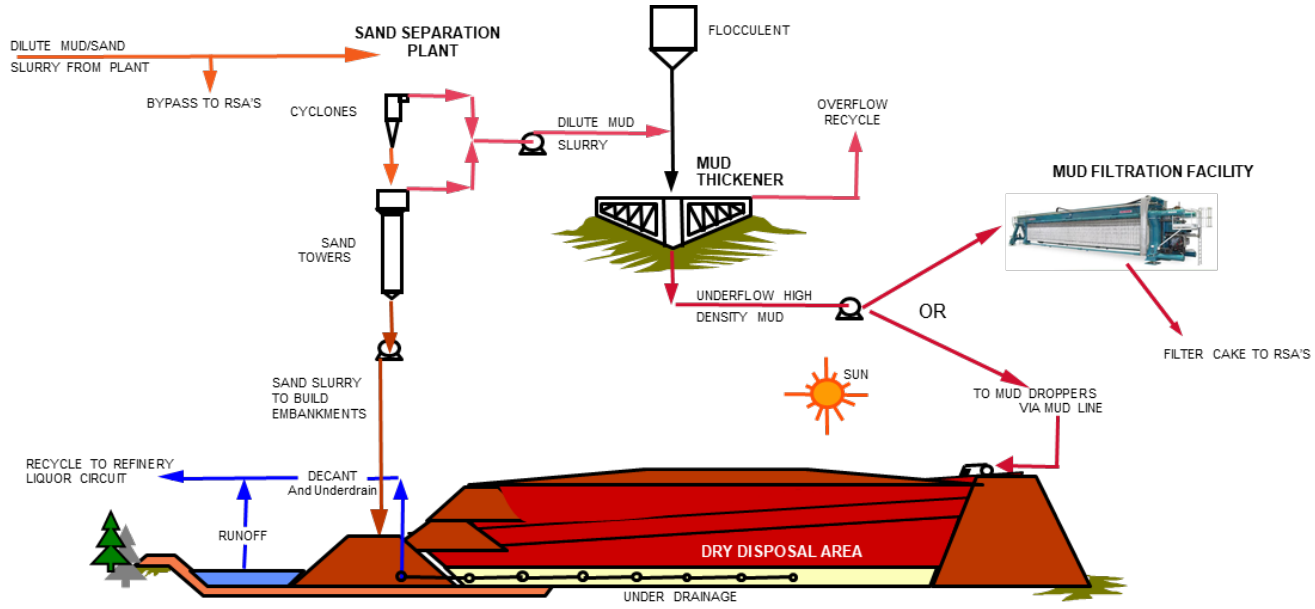

Figure 4-1: Schematic Diagram of the Kwinana Residue Processes

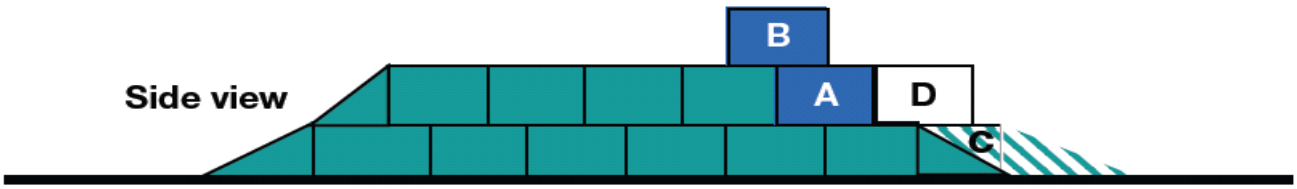

Figure 4-2: Residue stack development

Economic and Social Setting

5

5.1 Description of the Local Community

Kwinana refinery is located 22 kilometres south of Perth at the northern end of the Kwinana Industrial Area (KIA). The residue facilities are located approximately four kilometres east of the refinery. Both the refinery and the residue area are situated within the City of Kwinana, and the Western Trade Coast. The City of Cockburn boundary is approximately one kilometre to the north of the residue area.

5.1.1 Community Profile

Residential development in the City of Kwinana varies from relatively dense suburban development in the south to semi-rural properties adjacent to the north and eastern boundaries of the Alcoa residue areas with rural and suburban development east of the Kwinana freeway. The closest residences to the residue area are located on Mandogalup Road.

The City of Kwinana has a population exceeding 43,500 people within 120 square kilometres (ABS COK, 2018). Most people live in the suburbs of Medina, Orelia, Parmelia and Leda which are situated to the south of the residue area. Whilst a high proportion of the City of Kwinana population is of working age (median age 32 years), unemployment in the area is high (10.8 per cent) compared to the Australian average (6.9%) (ABS COK, 2016).

The City of Cockburn is located approximately one kilometre to the north of the residue area. The City of Cockburn has a much larger population than the City of Kwinana, with over 112,100 residents within 167.9 square kilometres (ABS COC, 2018). The median age is 36 and in 2016, the unemployment rate was 7.6 per cent (ABS COC, 2016).

5.1.2 Economic Profile

Kwinana refinery operations are located within the Western Trade Coast which is a 3,900-hectare industrial region located 30 minutes south of Perth with direct links to air, sea, road and rail networks.

The Western Trade Coast includes the KIA, Latitude 32 Industry Zone, Rockingham Industrial Zone and the Australian Marine Complex and is one of Perth's largest employment areas, employing over 11,000 people and contributing more than $15 billion per annum to the state's economy.

5.2 Heritage

5.2.1 Aboriginal Heritage

Kwinana has a large indigenous population, with nearly 4 per cent of the local population identifying as being of indigenous origin (ABS, COK 2016).

Wetlands known as The Spectacles are located two kilometres south east of the residue area. These wetlands are of particular significance to the local Aboriginal community. In the 1970s, the Industrial Lands Development Authority and Alcoa purchased the land for future industrial use. However, when the land was evaluated for residue drying purposes it became clear that it had high conservation value and was worthy of protection. Since this time, Alcoa has worked closely with state government departments to ensure The Spectacles wetland retains its high conservation value.

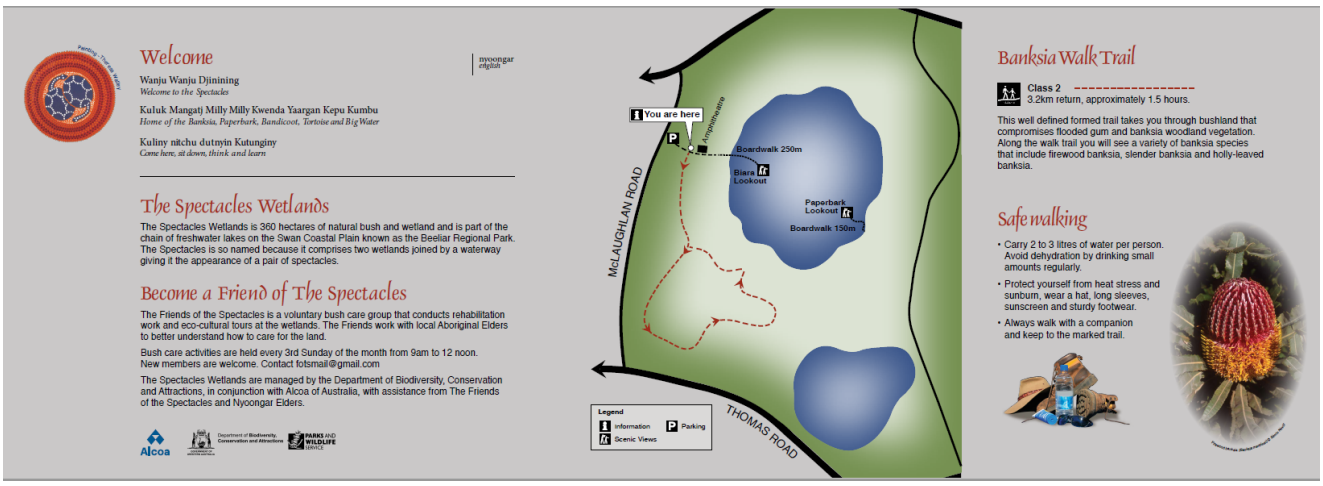

Figure 5-1: Spectacles Signage

Some of the relationships the Aboriginal people have with local ecosystems are displayed on a public Aboriginal walk trail around The Spectacles, developed by Alcoa in conjunction with local Aboriginal representatives and the then Department of Conservation and Land Management. In 2004, Alcoa sponsored The Spectacles Cultural Tours as part of the City of Kwinana's 50th anniversary celebrations and in 2018 Alcoa contributed to upgrading signage for the 10 year celebration of Friends of The Spectacles.

5.2.2 European Heritage

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

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

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

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

5.3 Overview of Alcoa's Economic and Social Contribution

5.3.1 Economic Contribution

Each year, Alcoa contributes greater than $2 billion to the WA economy through wages and salaries, taxes and royalties, and the purchase of goods and services.

In 2019, Kwinana refinery's contribution was approximately AU$127 million through salaries, wages and benefits and AU$356 million in supply contracts.

Kwinana refinery has a workforce of approximately 900 employees and 300 contractors. More than half of Kwinana refinery's employees live in the neighbouring communities of Kwinana, Cockburn and Rockingham. In addition to those employed directly by Alcoa, the City of Kwinana benefits significantly from the indirect employment generated by Alcoa, through its engagement of local contractors and purchase of local products and services.

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

5.3.2 Social Assessment Review

Stakeholder Perception Surveys are conducted periodically to help understand the perceptions and expectations of host communities and key stakeholders across our operations. The perception survey for the Western Australian operations conducted in 2019 engaged more than 800 stakeholders, including community members, through telephone and online surveys and in-depth interviews.

5.3.3 Partnerships and Volunteering

Kwinana refinery contributes to the local community through its partnership and volunteering programs in the areas of supporting a sustainable environment, community health and safety, community capacity and resilience, and tomorrow's workforce and leaders. Examples of partnerships active in 2019-20 are provided below:

Challenger Beach Rehabilitation and Restoration Project with Perth Natural Resource Management (NRM) and hosted by City of Kwinana

Focusing on conservation of the Challenger Beach Reserve, activities include planting and weeding, monitoring of fauna population, beach rubbish collection and coastal ecology education programs for local schools.

Castaways Sculpture Awards with City of Rockingham

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

Secret Harbour Surf Lifesaving Club – Starfish Nippers Program

The Starfish Nipper aim is to provide a water safety and awareness program for children from the age 6 and above. The program is designed to be inclusive of all abilities and needs in the local community.

Kwinana Industries Council iWomen Program

The Kwinana Industries Council iWomen Program provides local female students exposure to the resources sector as a possible career industry. The program helps participants look at what subjects / areas of study they should consider. The Refinery also facilitates a site tour and mock interviews.

Community Festivals

Alcoa provides financial support to annual festivals held in the local community, including City of Kwinana - Alcoa Children's Festival and the Coogee Live Festival.

Employee Volunteers

Alcoa also provides support to Alcoa employees who volunteer with local community organisations. In 2019 around half of the workforce volunteered in their local communities, contributing in excess of 9,800 hours.

Alcoa employees at a volunteering planting day at The Spectacles.

6 Environmental, Heritage and Planning Setting

Understanding the environmental, heritage and planning setting of the Kwinana 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 Kwinana operations.

6.1 Climate

Kwinana has a Mediterranean type climate characterised by hot dry summers and cool wet winters.

6.1.1 Temperature and Humidity

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

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

6.1.2 Rainfall

Rainfall in the region is seasonal, with the majority of rain falling during the winter months (June to August). The long-term average annual rainfall for the area is 749 mm over the 1984-2018 period (measured at the Medina Research Centre prior to 2 May 2018 and Wattleup Station from 3 May 2018). Rain-free months are not uncommon and have been recorded from December through to February. Mean daily evaporation ranges from 8.5 mm/day in January to 1.8 mm/day in June and July. The mean annual evaporation is 4.8 mm/day (Bureau of Meterology, 2011).

6.1.3 Wind

Two processes cause winds in the Kwinana region:

Large scale synoptic winds (due to the movement of high and low pressure systems across the State); and

Local winds (induced by topographical features and by land and sea breezes).

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

6.2 Geology, Soils and Topography

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

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

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

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

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

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

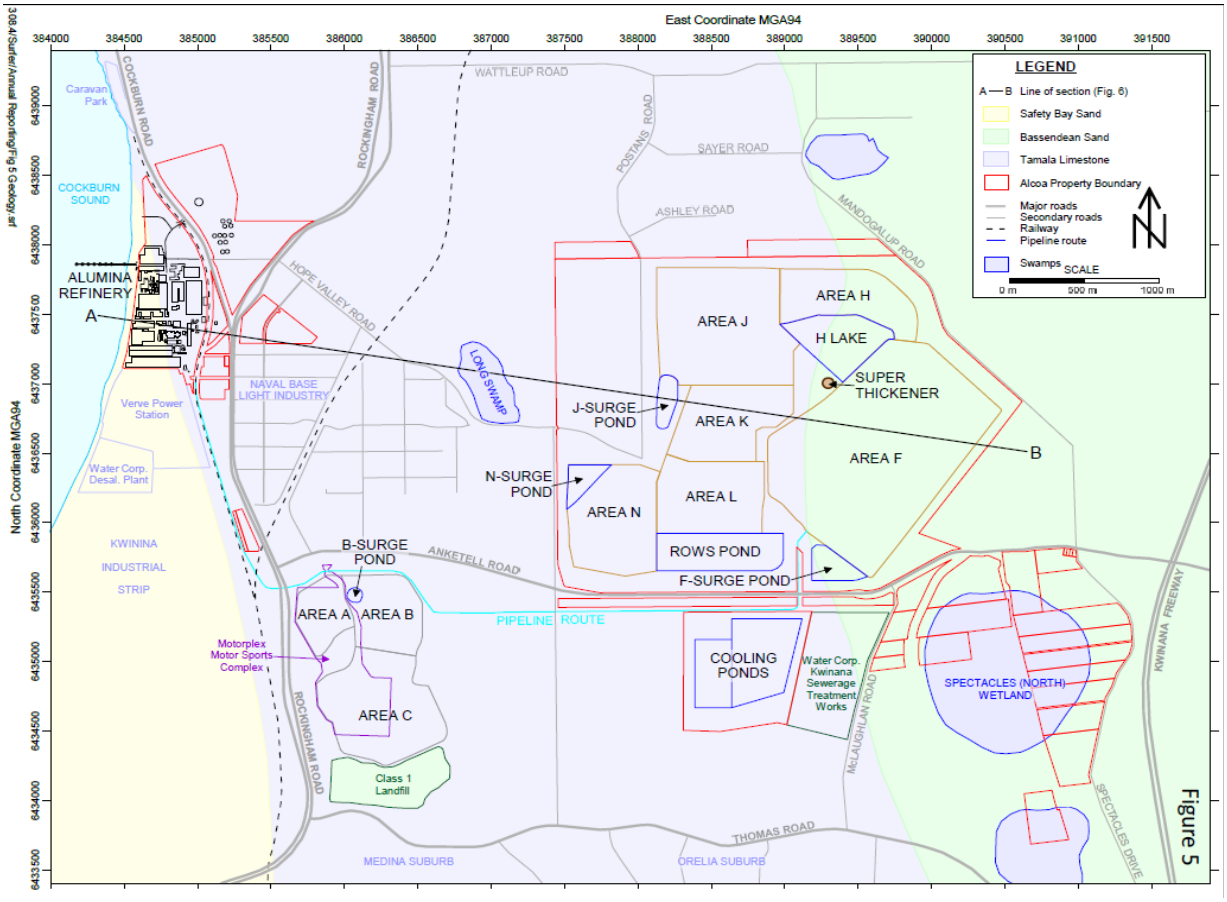

Figure 6-1: The geology at the water table

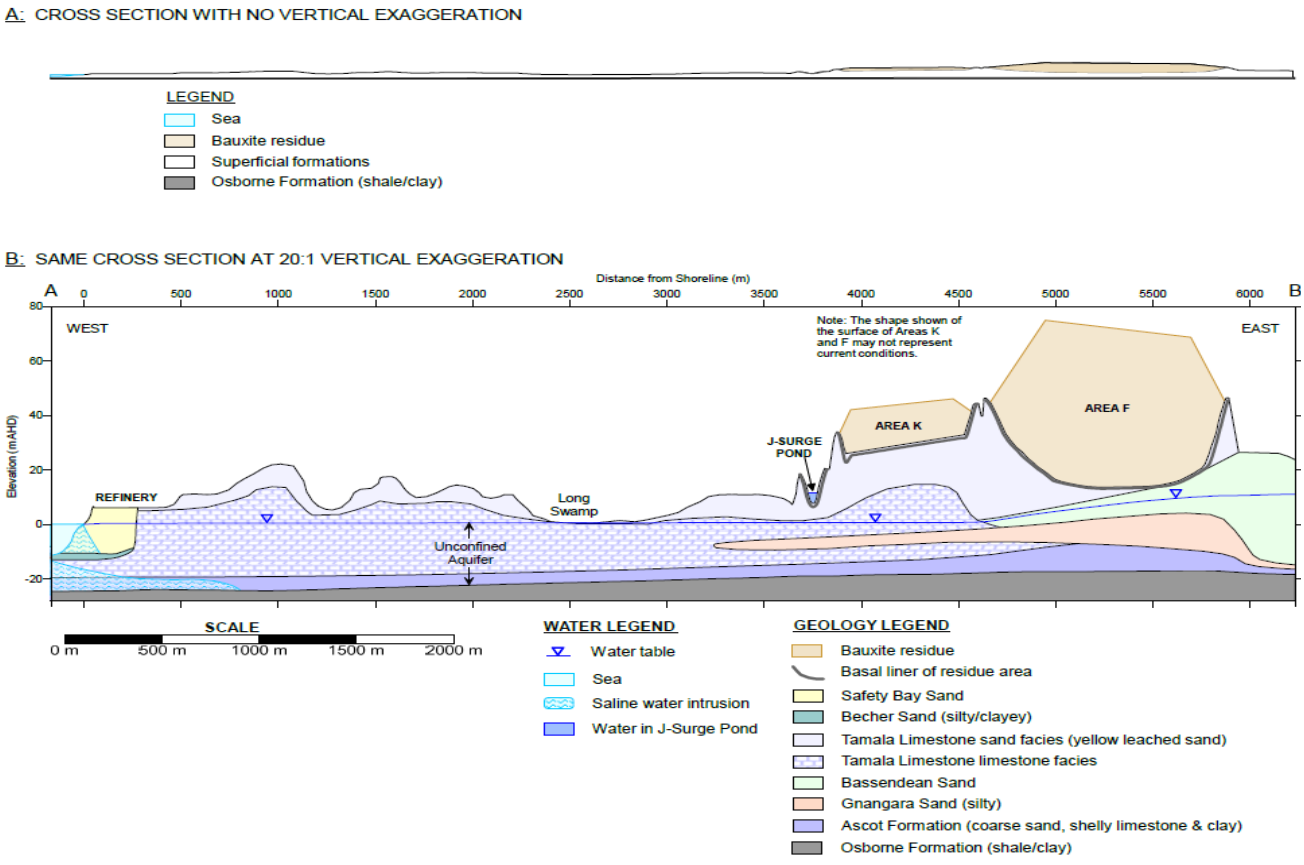

Figure 6-2: Hydrogeological cross section from the refinery to the eastern side of the operating Residue Storage Areas

6.3 Hydrology

6.3.1 Groundwater

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

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

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

Saline water intrudes into the unconfined aquifer from the sea. The main wedge of saline water on the base of the aquifer intrudes up to one kilometre from the coastline. As groundwater approaches the coast it flows above the saltwater intrusion wedge and discharges at the shoreline or slightly out to sea. The saline intrusion wedge is a natural feature, but it is dynamic, and the thickness and landward extent responds to changes in the difference in height between the water table and sea level.

6.3.2 Surface Hydrology

The wetlands of the area, including The Spectacles to the south east of the residue area and Long Swamp to the west of the residue area, are topographic low points where the water table meets the ground surface.

As groundwater in the region flows in a westerly direction, The Spectacles are located above or up hydraulic gradient of the residue area and Long Swamp is located below or down hydraulic gradient of the residue area.

6.4 Flora and Fauna

6.4.1 Flora

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

Floristic surveys (Bennett Environmental Consulting Pty Ltd, 2002) identified six main vegetation communities in the region:

1. Low Open Forest of Eucalyptus marginata (commonly known as Jarrah) and Banksia attenuata (Candlestick Banksia) over an Open Heath dominated by Xanthorrhoea preissii (Grass tree) or Acacia pulchella (Prickly Moses) in greyish brown sand.

2. Woodland of Eucalyptus gomphocephala (Tuart), Eucalyptus marginata (Jarrah), Banksia attenuata (Candlestick Banksia) and Allocasuarina fraseriana (Sheoak) over an Open Heath dominated by Xanthorrhoea preissii (Grass Tree), Macrozamia riedlei (Zamia Palm) and Acacia pulchella (Prickly Moses) in brownish yellow sand.

3. Woodland of Eucalyptus gomphocephala (Tuart) and Eucalyptus marginata (Jarrah) with occasional to dense Banksia attenuata (Candlestick Banksia) over a Shrubland of mixed species dominated by Xanthorrhoea preissii (Grass Tree) and Macrozamia riedlei (Zamia Palm) in brownish yellow sand.

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

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

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

Complex 6 is listed as a Threatened Ecological Community (Floristic Community Type 26a).

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

6.4.2 Fauna

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

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

Since 2002 periodic fauna and flora surveys have been undertaken to gather information to develop recommendations for ongoing management of vegetation and fauna or for specific projects. Each survey has focussed on different areas, which have included the native vegetation along Anketell Road, the, the Threatened Ecological Community, the rehabilitated area to the east of Abercrombie Road, the area proposed for the future Area O and the Wellard area.

6.5 Heritage Sites

6.5.1 Aboriginal Heritage

Alcoa has commissioned several Aboriginal Heritage studies of the areas in close proximity to the residue storage area in recent years. Typically, past studies were conducted through archival searches of the Department Planning, Lands and Heritage (DPLH) (formerly Department of Indigenous Affairs (DIA) site register; consultation with Aboriginal heritage consultants and Traditional Owners; and field surveys of areas proposed for development. These surveys focussed on the identification of any archaeological or ethnographic sites in the study areas and were conducted in accordance with the guidelines at the time.

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

6.5.2 European Heritage

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

6.6 Existing Land Use and Tenure

Alcoa's owns several landholdings within the Kwinana-Rockingham area, ranging from the refinery site located within the Kwinana Industrial Area, to rural land from which clay is extracted for use in the construction of residue areas.

The existing operating residue area footprint is 346 hectares. The residue area is under freehold ownership by Alcoa and is zoned Rural B for bauxite residue drying and storage. Most of the property surrounding Alcoa's residue area is privately owned.

6.7 Local, Regional and State Planning Policies and Visions

The development of the LTRMS, and final land use planning objectives, are informed by current planning policies and visions for the region.

Together with a commitment to best practice environmental controls, compatible land use planning is considered necessary to prevent conflict from urban encroachment on industrial operations. Compatible development does not seek to quarantine land from development, but to ensure the land use(s) and intensity of activities thereon, remains appropriate to operational risks, preserving and enhancing the orderly and proper planning of the locality.

6.7.1 Metropolitan Region Scheme

The Metropolitan Region Scheme (MRS) is a planning scheme for the Perth metropolitan area. The MRS includes the whole of the Kwinana residue area and surrounding land. The MRS can be used to apply regional land use planning objectives and sets out the intended future use of land by defining it into broad zones and reservations. It requires local government town planning schemes to provide detailed plans for their part of the region. These schemes must be consistent with the MRS.

Alcoa Kwinana residue area is classified Rural under the MRS (DPLH, 2020).

6.7.2 Perth and Peel @3.5 million and South Metropolitan Peel Sub-Regional Planning Framework

Perth and Peel @ 3.5m sub-regional land use planning and infrastructure frameworks published in 2018, provide the strategic context and basis for the coordination and integration of land use planning and development across State, regional and local jurisdictions.

The South Metropolitan Peel SubRegional Planning Framework (SMPSPF) was released in March 2018. It forms part of the Perth and Peel@3.5million. It recognises that "The Western Trade Coast is the only Strategic Industrial Area (SIA) in the Perth and Peel regions. This and other regional SIAs are of significant economic and strategic importance to the State and are protected through buffers or industry protection areas from urban encroachment and sensitive land uses."

The SMPSPF identifies the operating residue storage area and part of the retired residue area as existing industry. South, west and north west of the operating residue area including the future residue areas is identified as industrial expansion and includes the future residue storage areas. The area north east and east of the operating residue storage area is denoted as industrial investigation.

6.7.3 Hope Valley Wattleup Master Plan

The Western Australian Land Authority (now DevelopmentWA) prepared the Hope Valley Wattleup Redevelopment Project Master Plan (HVWMP) 2004 (amended May 2020). In accordance with the Environmental Protection Act 1986, an Environmental Review was also prepared which describes the HVWMP and its likely effects on the environment.

The HVWMP aims to:

(a) protect the Kwinana Industrial Area by resolving surrounding land use conflicts;

(b) protect significant heritage in the Redevelopment Area;

(c) conserve areas of local and regional environmental significance;

(d) minimise sources of pollution;

(e) distribute the cost of common infrastructure;

(f) ensure the development and use of land within the Redevelopment Area comply with accepted standards and practices;

(g) ensure that future development and land use within the Redevelopment Area occur in a proper and orderly way;

(h) promote sustainable development; and

(i) facilitate development generally in accordance with the HVWMP Report and Planning Strategy.

The HVWMP divides the Redevelopment Area into precincts to identify areas for particular uses and identifies land reserved for public purposes. Most importantly, the HVWMP controls the types of uses and development allowed in the various precincts. The HVWMP sets out the requirements for planning approval, nonconforming uses and enforcement of the HVWMP provisions.

Most land within the HVWMP is earmarked for general industrial use. Within the immediate vicinity of the residue area, the HVWMP identifies general industry to the west where the Latitude 32 Industry zone redevelopment is located, low intensity business park to the north and an area north of Rowley Road where the final land use was subject to the Environmental Protection Policy (EPP) Buffer Review process.

6.7.4 State Planning Policy

State Planning Policy 4.1 – State Industrial Buffer Policy (SPP4.1) was adopted in 1997 to provide a consistent state-wide approach for the protection and long-term security of industrial zones, transport terminals (including ports), other utilities and special uses. It also provides for the safety and amenity of surrounding land uses while having regard to the rights of landowners who may be affected by residual emissions and risk.

In 2017, the WAPC released *Draft State Planning Policy 4.1 – Industrial Interface* (Draft SPP4.1) for public comment. SPP 4.1 guides planning decisions with the aim of protecting the long-term future operation of industry and infrastructure facilities, by avoiding encroachment from sensitive land uses and potential land use conflicts.

6.7.5 Kwinana Industrial Buffer

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

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

The Review of Kwinana Air Quality Buffer was released for public comment in August 2002. The review recommended modification to the existing buffer in six areas and identified three additional areas which were subject to further investigation.

To take into account changing circumstances and available information review of the buffer to the north, northeast and east of Alcoa's Kwinana residue area and around the Water Corporation's Wastewater Treatment Plant, the 2008 review proposed the extension of the buffer in some areas and its retention in others, and recommended the buffer be reconsidered following further investigations. The 'Position Statement - Review of the Kwinana Air Quality Buffer' (October 2008) includes the 1 kilometre buffer to Alcoa's residue area and further investigation for the area (Area 9) beyond the 1 kilometre.

A further review was finalised in September 2010, after the Western Australian Planning Commission considered technical advice from the Department of Health and Department of Environment and Conservation and a dust study undertaken by GHD on behalf of Alcoa in 2008 and 2009 submitted to the Kwinana Air Quality Buffer Steering Committee in early 2010. This study showed that dust emanating from Alcoa's residue area could, under certain weather conditions, be detected up to 2km away.

The expanded buffer included a 1-kilometre area around the residue area where future residential expansion is restricted, with an additional 0.5 kilometre beyond this that restricts residential expansion and development of some sensitive land uses (e.g. kindergartens, hospitals and aged persons housing). The purpose of the additional area was to recognise uncertainties inherent in the level and frequency of impacts from Alcoa's residue area and the Kwinana Industrial Area more broadly. The review expanded the buffer in these areas.

In 2014 the Kwinana Industries Council Metropolitan Scheme Amendment to create a special control area over the Western Trade Coast to get the Western Trade Coast industrial buffer zone protected was considered and rejected in 2019. The Application was revised and resubmitted in mid-2019.

The Western Australian Environmental Protection Authority (EPA) released its advice to the Minister under section 16(e) of the Environmental Protection Act 1986 "Consideration of potential health and amenity impacts of dust in determining the size of a buffer for urban development in the Mandogalup area" and Supplementary Information (June 2017) reports. Further investigations were undertaken by the Department of Water and Environmental Regulation (DWER), who undertook a dust monitoring campaign for a period of four (4) months over the 2017/18 summer period in the Mandogalup Area. The dust monitoring campaign outcomes were reported in "Mapping dust plumes at Mandogalup using a LiDAR" (January 2019).

In April 2019 an area of land zoned urban deferred in the Metropolitan Regional Scheme was rezoned to urban, which coincides with Area A in the EPA's Section 16(e) advice and the 0.5 km buffer transition zone to urban. The Mandogalup Area to the east of the residue area which coincides with Areas B, C and D in the EPA's Section 16(e) advice and the 1 km buffer is currently subject to the Western Australian Planning Commission Improvement Plan 47 (IP47) process[1].

Alcoa did not support the erosion of the 0.5km transition zone and does not consider the proposed future land use and population density within the IP47 planning area as compatible with residue storage. Planning principles for the area need to put the day-to-day dust and amenity considerations which underpin the buffer alongside public safety considerations should a low likelihood worst case scenario ever eventuate to minimise individuals at risk. Since the high-profile dam failures in Brazil, the International Council of Mining and Minerals have been attempting to reduce the populations in the vicinity of impoundment facilities.

6.7.6 Local Planning Schemes

City of Kwinana Town Planning Scheme

The City of Kwinana Town Planning Scheme No. 2 establishes a Rural B zoning over the residue area.

Land purchased to the West of the operating residue areas for future Areas O and P and associated water storage has also been zoned "Rural B".

The local planning scheme proposed for the area to the east of residue in 2018 is dependent on the outcome of the IP47 process.

City of Cockburn Town Planning Scheme

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

Land located just north of the City of Kwinana-Cockburn boundary along Wattelup Road is within the City of Cockburn's Development Zone. Some of this land proposed for subdivision for residential development falls within the 0.5 kilometre residential development and sensitive use exclusion area of the revised Kwinana Industrial (including Air Quality) buffer.

6.7.7 Land Use Planning Guiding Principles

Guiding Principles developed by the SRG for Residue Area Development which includes land use planning considerations can be found in Section 8.8.

1 Note: The LTRMS consultation did not seek to resolve any State Government IP47 planning considerations.

7 Existing Environmental Issues & Management Strategies

7.1 Environmental Management Systems

Environmental management of the residue facilities is through a comprehensive ISO14001:2015 certified 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 1995. Subsequently, the EMS was extended to the remainder of the Kwinana Refinery, which gained ISO 14001 certification in December 1997. The key elements of the system are:

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

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

7.2 Dust

7.2.1 Background

Dust generated from the residue area mostly consists of fine clay particles and some sodium carbonate crystals precipitated on the surface of residue as entrained moisture evaporates. Residue dust is slightly alkaline and could be an irritant if high enough concentrations occurred – however extensive monitoring data shows this is very unlikely as the level of dust emitted from the residue area is well below the level likely to cause any health impacts. For more information on residue emissions and health, see section 7.5.

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

Wind speeds in excess of 6.5 m/s (23 km/h) can pick up and transport fine residue and carbonate particles from dry residue surfaces. The distance over which these particles are transported depends on a variety of factors including atmospheric conditions and the size, shape and mass of the particles. It is also known that other neighbourhood dust that has not originated from the residue areas is weather dependent, which indicates that these neighbourhood sources also have a significant wind erosion dust component (GHD, 2009).

The months from October to April are considered to be the time of the year when the risk of airborne dust generation is potentially greatest. In summer, the predominant winds are moderate to strong east-south-easterly winds and moderate south-westerly winds. Strong and gusty south-westerly winds develop around midday with the onset of the sea breeze which eases in the late evening. The speed of these winds together with the higher ambient temperatures over summer, and therefore faster mud drying rates, require careful control mechanisms to be in place to prevent dust being released.

Alcoa's Kwinana Refinery received a total of 54 complaints related to dust from the residue areas between 2005 and 2011. The annual number of dust complaints has decreased since 2008. Between 2012 and 2019 nine residue dust complaints have been received.

Despite the potential for the residue area to generate dust, the 2009 GHD Dust Study demonstrated that there are many significant neighbourhood dust sources near the residue areas and monitoring has shown the residue area has similar significance to other neighbourhood dust sources, such as quarries and market gardens (GHD, 2009). No health complaints have been registered with the refinery since 2008.

7.2.2 Current Management Strategies

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

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

Long-Term Controls (annual)

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

- appropriate dust control mechanisms are in place for any newly constructed or exposed embankments;
    - new or exposed internal embankments likely to remain in place undisturbed for an extended period are planted with native vegetation or grasses during winter to allow them to establish an effective long-term dust control cover;
    - embankments or areas that are not required in the shorter term are covered with crushed rock aggregate or woodchips (mulch); and

Mid-Term Controls (weekly)

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

Alcoa utilise seven day and seasonal weather forecasts. These are reviewed weekly and allow Alcoa to maintain preparedness for conditions conducive for dust generation by, for example, operating sprinklers well ahead of forecast winds.

In addition, the following specific mid-term dust control methods are employed by Alcoa to minimise dust generation:

- turning over the mud in the drying area thereby leaving wet mud on the surface;
- spraying exposed banks and roads with dust suppressants;
- applying mulch
- minimising vehicle access to exposed areas; and
- investigations into target exceedances of targets to prevent reoccurrences.

Day-to-Day Controls

Alcoa uses weather forecasting to consider Dust Risk, taking into account rain, wind speed and wind direction.

The main day-to-day control mechanism to manage dust emissions from the solar drying beds is the use of the sprinkler system. The sprinkler system is operated in response to daily weather forecasts and residue area conditions

Figure 7-1: A Residue Dust Monitor

and continuous dust monitors around the residue area. Internal alarms are triggered in the event of dust levels above internal targets. Sprinklers are operated in response to alarms and proactively to wet down areas prior to forecast weather conditions.

Ambient Dust Standards

Ambient dust monitoring at the Kwinana residue area and regulatory reporting is carried out in accordance with the Environmental licence conditions. Current conditions set dust target levels for total suspended particles (TSP) at 90 µg/m^3 (24 hour average, non-background corrected) as determined by continuous monitoring at licensed high volume (Hi-Vol) samplers. The current residue dust monitoring network comprises five Ambient Hi-Vol dust monitors measuring (TSP) and with Real Time PM_{10} monitors located North and West of the residue area.

Dust Performance

All licence dust monitoring data is summarised and presented in annual environment reports to the DWER.

In 2019 there were 39 average daily dust concentrations above the targets at licensed monitors around the residue area. Following investigation two of these were determined to be potentially contributed to by Alcoa residue operations and reported to DWER. Residue dust was suspected to have contributed to one of these target exceedances with non-Alcoa activities suspected to have contributed to the other.

Dust monitoring results are presented at the EIP meetings.

7.2.3 Alcoa Residue Dust Studies

WAO Residue Dust Study

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

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

Kwinana Residue Dust Studies

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

In 2004, Sinclair Knight Merz (SKM) studied and modelled Kwinana residue area dust emissions.

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

GHD was tasked with expanding, extending and improving previous dust models to increase confidence in the dust emission predictions. The objective of the study was to assess the extent and magnitude of dust emissions that may relate to health or amenity concerns from existing or potential neighbours. In doing this, the study led to improvements in the predictions relating to the extent of dust impacts and provided a better understanding of the dust generating processes at the residue area. The outcomes of the study are intended to inform land use planning decisions in adjacent areas, modification of dust management techniques and adaption to potential climate changes in future years.

Alcoa submitted this study to the Kwinana Air Quality Buffer Steering Committee for consideration in its review of the Kwinana Industrial (including Air Quality) Buffer in early 2010 (see Section 6.7.5 for more detail).

7.2.4 Dust Management Guiding Principles and Alcoa's Response

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

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Dust Management**	
1	Alcoa acknowledges that dust management is important to the SRG and commits to ongoing communication regarding dust management and responsiveness to community comments.	Alcoa acknowledges dust management is important to the stakeholders. Alcoa will continue to communicate dust management performance through existing stakeholder engagement processes and other relevant communication and feedback processes.
2	Alcoa to use best endeavours to contain emissions on site in accordance with relevant standards.	Alcoa regularly reviews its dust management processes and practices with the objective of continuously improving dust management at the residue areas. Alcoa will continue to monitor dust in accordance with environmental licence conditions.
3	Alcoa to continue to improve dust management including exploring new technology and best practice.	Alcoa regularly reviews its dust management processes and practices with the objective of continuously improving dust management at the residue areas.
4	Alcoa to consider the impact of climate change on residue dust management regarding unknown wind and weather patterns.	Alcoa works with weather forecasting providers to improve the accuracy of forecasts and adapts its short, medium and long-term dust management responses accordingly.
5	Alcoa to communicate to stakeholders its contingency plan for failure or inaction of current residue area dust management practices.	This LTRMS document includes information regarding Alcoa's dust management practices.

7.3 Odour & VOCs

7.3.1 Background

Odour comes from a range of compounds, including some volatile organic compounds (VOCs), and may be an amenity concern for the local community.

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

7.3.2 Residue Odour and VOC Emissions

The higher sources of odour for Kwinana are likely to include the cooling pond and super-thickener. Lower sources of odour at the Kwinana residue area are likely to include the wet drying areas, dry residue areas and low concentration cool liquid sources (for example lake water pond and surge ponds). Monitoring of the Oxalate bioremoval process confirmed that it is not a significant source of odour. Overall,odour emissions from the Kwinana residue were not regarded as significant by the SRG, and Alcoa's community complaint data supports this.

Post the installation of the ROWS pond in 2006 Alcoa reduced its use of cooling pond water in sprinklers for dust suppression to decrease odour and VOC emissions from residue areas. The introduction of Residue Filtration reduces the reliance on traditional mud drying areas and the associated use of sprinklers for dust suppression.

7.3.3 Impact of Expanded Residue Footprint on Odour and VOC Emissions

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

No guiding principles were developed by the Kwinana LTRMS SRG relating to odour and VOCs.

7.4 Radiation

7.4.1 Background

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 per cent 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.

The accepted international and national radiation limit for occupational exposure is 20 mSv (millisieverts) averaged over a period of five consecutive calendar years. The accepted international and national radiation limit for the general public is 1 mSv per annum (above background). All personal exposure readings for the Alcoa residue workforce are within the limit set for the general public. That is, readings have been more than 20 times less than the limit allowed for workers (Alcoa, 2004).

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

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

7.4.2 Impact of Expanded Residue Footprint on Radiation Emissions

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

No guiding principles were developed by the Kwinana LTRMS SRG relating to Radiation

7.5 Residue Emissions and Health

7.5.1 Background

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

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

Some compounds such as acetaldehyde have low odour thresholds and can be detected at concentrations which are too low to cause health effects. Similarly, larger dust particles can cause an amenity impact even though they do not constitute a potential health impact.

In 2004 Alcoa voluntarily committed to a major research program aimed at further improving its understanding of the contribution made to regional dust by its alumina refineries in WA. An independent Health Risk Assessment (HRA) was then performed to investigate the health risks associated with residue dust. A summary of the results is presented below.

7.5.2 Residue Dust Study

It was decided to focus the research at one refinery, Pinjarra, with input from other sites as necessary to validate the general conclusions. A monitoring site at Kwinana was used in order to observe the effect on dust of being near the sea, other industries and urban activities in contrast to a rural setting near Pinjarra.

Monitoring ran over 18 months from mid-2005 to December 2006, capturing two winter/spring/summer periods and one autumn. It has since been shown that 2006 was an atypical year for dust with stronger winds than average, combined with significant construction activity, problems with parts of the residue area sprinkler control system and other factors leading to higher dust levels. The dust study results can therefore be regarded as conservative.

The program was run for Alcoa by experienced accredited consultants. Three companies were involved, each being highly regarded within their area of expertise:

- Ecowise Pty Ltd – dust sampling and sample analysis;
- Air Assessments Ltd – data evaluation, meteorological and statistical analysis; and
- Environ Ltd – health risk assessment.

All methods, analysis and calculations were performed to Australian Standards and National Association of Testing Authorities (NATA) testing accreditation performance requirements. Samples collected to analyse the composition of the dust were performed using:

- High Volume Air Samplers – 7 day and selected 24-hour samples;
- Low Volume Air Samplers – 7 day and selected 24-hour samples;
- Deposition – monthly;
- Grab Samples from the residue area and surrounding areas; and
- Water – following rain.

The key conclusions from the Residue Dust Study were as follows:

- There is a very low $PM_{2.5}$ fraction in RSA dust. $PM_{2.5}$ emissions from the residue areas are well below advisory criteria and not an issue of any significance;
- Use of up-wind and down-wind Tapered Element Oscillating Microbalances (TEOMs) worked well & indicated that the residue area can contribute the majority of total suspended particulates (TSP) and PM_{10} during 1-hour and 24-hour dust events, but is a much smaller contribution to annual average concentrations and to $PM_{2.5}$; and
- The best individual chemical marker for residue dust appears to be the trace element thorium, which though present at very low concentrations, is relatively easy to analyse for.

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

7.5.3 Health Risk Assessment Results

A Health Risk Assessment (HRA) is a risk assessment process that compares the ground level concentrations (GLCs) of compounds with their health guidelines set by national and international health agencies. The GLCs are predicted by air dispersion computer modelling. The HRA considers the:

- risk of short-term (acute) health effects in relation to short-term exposures (1-hour & 24-hour averages);
- risk of long-term (chronic) health effects in relation to long term exposures (annual averages); and
- incremental risk of cancer in relation to long term exposures (annual averages over 70 years).

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

The HRA considered inhalation exposure to the following substances/elements:

- PM_{10} (Particulate Matter < 10 µm diameter); and
- The metals arsenic, selenium, manganese, cadmium, nickel, mercury, chromium, beryllium, lead and vanadium.

Other metals analysed but for which health guidelines are not available were not included in the HRA. Based upon the results of the HRA it can be concluded that:

- the potential for emissions from the baseline or expanded residue area to cause acute health effects presents no cause for concern;
- the acute Hazard Index (HI) is primarily driven by exposure to PM_{10}, not to individual metals in residue dust;
- the potential for emissions from the baseline or expanded residue area to cause chronic health effects represents no cause for concern; and
- the potential for emissions from the baseline or expanded residue area to contribute to the incidence of cancer based on inhalation exposure is low, below the United States

Environmental Protection Agency (USEPA) de minimis threshold of one in a million (i.e. 1 x 10-6).

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

In response to the information provided, the Kwinana LTRMS SRG determined that a guiding principle around health impacts of residue dust was not required.

7.6 Waste

7.6.1 Background

Waste generated at the Kwinana refinery can be broadly categorised as either non-process waste or process waste. Non-process waste includes laboratory wastes; office; wood; garden; food wastes; and sewage.

Process wastes from the refinery include waste that is generated from alumina production and associated activities, e.g. Scale (any solid material from process circuits or tanks that contains caustic); waste alumina and hydrate; and oxalate.

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

7.6.2 Current & Future Management Strategies

Non-Process Waste

The Kwinana residue area operates a licensed Class II landfill area which takes Class II wastes generated from the refinery and residue area such as non-recyclable non-process wastes.

On site waste disposal reduces pressure on municipal landfills. The overall volume of waste disposed to the landfill is less than 1 per cent of total residue produced per annum. Alcoa has a significant ongoing focus on reduction of waste to landfill through new and improved recycling programs with advances having been made in the area of waste recycling and minimisation.

Alcoa's waste management program includes the recycling of waste oil, scrap metal, conveyor belt fluorescent lights, automobile batteries, liquid waste, electronic waste, cardboard, cooking oil and printer/toner cartridges. Alcoa also operates a worm farm and composting facility at its Pinjarra refinery that collects and processes all organic based waste produced at each of Alcoa's locations in Western Australia. Details of waste materials are recorded in a comprehensive database. Recyclable material is classified and separated prior to removal from site and the remnants are disposed to the Class II landfill area within the residue area.

Process Waste

A separate tip face, which does not form part of the Class II landfill, accepts process wastes derived from the alumina production and associated activities. While Alcoa's corporate goal is to reduce landfilled waste, Alcoa also recognises that there are opportunities to track and reduce process waste and the oxalate bio-removal process is an example of process waste minimisation.

Oxalate

In the past, oxalate has been managed using several techniques:

- Oxidised using an Oxalate Kiln;
- Reacted with lime (to form calcium oxalate) and stored within residue mud;
- Sold to a third party for use in an industrial process; and
- Stored in oxalate ponds for future destruction.

Alcoa has constructed and commissioned an oxalate bio-removal plant at Kwinana to destroy oxalate. The plant was commissioned in 2009 and was the first plant of its kind in the world. Bio-removal is a bacterial process that breaks down the sodium oxalate to sodium carbonate and sodium bicarbonate.

The Kwinana refinery's operating licence allows for storage of oxalate in ponds and processing via the bio-removal plant.

7.6.3 Waste Guiding Principles and Alcoa's Response

In response to the information provided, the Kwinana LTRMS SRG developed one Guiding Principle relating to waste presented below, together with Alcoa's response.

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Waste Management**	
6	Alcoa to consider suitable waste to go to Avertas Energy waste to energy plant.	Alcoa has a focus on reducing waste to landfill through recycling programs and waste minimisation efforts, including assessing the viability to use new facilities such as waste to energy plants e.g. Avertas Energy.

7.7 Water Use

7.7.1 Background

Alcoa focuses on using water of a quality that is fit for purpose and substituting higher quality water with lower quality water where possible.

The Kwinana refinery operates an efficient closed water circuit, i.e. maximising reuse of process water without discharging effluent. The circuit is supplemented with water to make up for water losses. Water sources for the refinery include rainwater that falls on the refinery and residue areas; ground water recovery and production bores on site; potable water; and water brought in with bauxite. The only losses of water from the refining system are as steam and moisture from the refining process, evaporation from water storage areas and residue surfaces, and water bound within the residue mud and sand. The largest use of water at the residue facilities is for operating sprinklers to control dust.

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

7.7.2 Current Management Strategies

Water use for the sprinkler system increased significantly post the 2006 sprinkler upgrade and in response to more conservative dust management practices. While this resulted in a significant improvement in dust management, the current dust management focus is now on maintaining dust performance while optimising water use.

Alcoa installed and commissioned the ROWS pond in 2006 to increase water storage capacity and allow sprinklers to be run on production bore water, good quality recovery bore water and good quality condensate. This reduces carbonate formation and risks of overspray. Sprinkler spacing was also revised to improve efficiency.

Residue Filtration has also reduced water use as some of the moisture previously lost to evaporation is now recovered during filtration for reuse in the refinery processes and there is no need for sprinklers coverage in the areas where filter cake is deposited, as alternative dust suppressants are used to manage dust in these areas.

As part of the Water Corporation's Waterwise Business Program Alcoa has developed a Water Efficiency Management Plan for managing potable water efficiently and reports on progress annually.

Impact of Expanded Residue Area

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

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

Residue filtration processes reduce the rate of development of new drying areas as the current area footprint can be more efficiently used with the reduced need in surface area and time required for the drying cycles associated with open mud drying areas.

7.7.3 Water Guiding Principles and Alcoa's Response

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

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Water**	
10	Alcoa to continuously improve processing technology to reduce water requirements.	Alcoa will continue to focus on water efficiency by maximising water conservation and the use of recycled and fit for purpose water. Residue filtration has resulted in a reduction of water used in our operations.

7.8 Surface Water

7.8.1 Background

The Kwinana refinery operates a closed water circuit, meaning that the refinery does not discharge any process water from the site. Stormwater that runs off the residue or refinery process areas is characteristically alkaline. This renders the water unsuitable for direct discharge to the environment. Therefore, all rainfall runoff from the refinery and residue process areas is collected and stored in lined ponds within the residue area for recycling via the refinery process as make-up water.

7.8.2 Current Management Strategies

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

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

Surface water runoff and underdrainage is collected in Surge Ponds and pumped or drained to the Cooling Pond.

Under normal rainfall conditions water collected on the surface of the RSAs is allowed to drain freely to the associated Surge Pond. Under severe storm conditions water may need to be retained in the RSAs by closing the decant weirs to prevent an unmanageable amount of water reporting to the Surge Ponds. Operational guidelines define the requirements for storm surge capacity requirements, typically catering for the residue area to capture 100% of any storm event, based on a 1:100 year 72 hour storm and a 10 day post storm event recovery period.

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

Whilst Alcoa intends to maintain a no discharge operation, Alcoa sought approval and in 2020 installed a spillway on the Cooling Pond in line with ANCOLD guidelines to reduce the risk of embankment failures due to overtopping in the event of low likelihood extreme weather events.

7.9 Groundwater

7.9.1 Background

Western Australia's water resources are considered a valuable public asset. Groundwater of useable quality is present in the superficial strata within the region of the existing and proposed residue deposits. Groundwater management and abstraction are regulated by the Environmental and Abstraction Licenses and the Contaminated Sites Act.

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

The need to contain the residue leachate meant that the embankments were originally designed as water retaining structures adding further conservatism to their design. Their construction included base and embankment clay sealing layers.

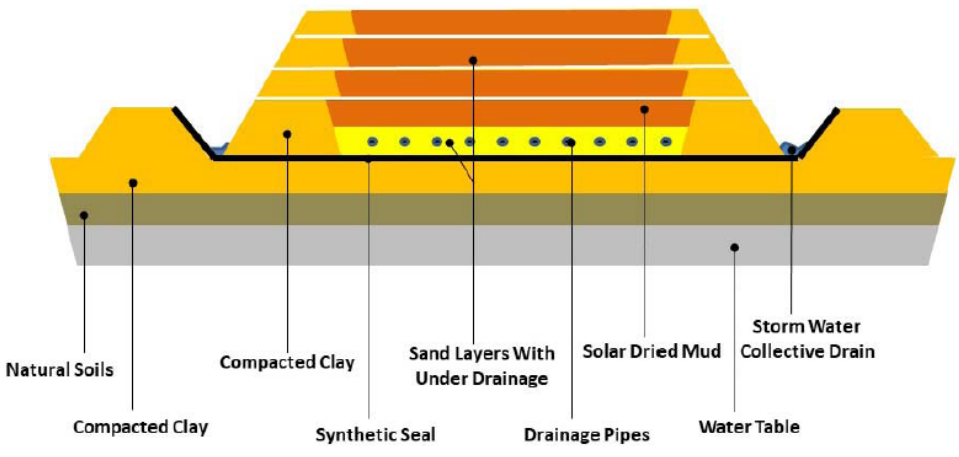

Figure 7-2: Schematic showing construction method of a typical residue drying bed

The introduction of solar drying of thickened of residue mud 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. The residue filtration process provides similar benefits as the moisture level of the residue material is reduced prior to deposition of a stackable filter cake.

Drying areas constructed post 1980 have base drainage systems. These drainage systems provide a major defence against seepage to the ground water by substantially lowering the hydraulic head at the base of the deposit. All RSAs constructed since 1983 have also included uPVC/PVC or HDPE liners to further mitigate seepage. A schematic representation of one of the typical RSA construction methods is provided in Figure 7-2.

7.9.2 Current Management Strategies

Alcoa has a Groundwater Monitoring and Management Plan for the Kwinana refinery. The objective of this plan is to monitor, contain, control and reduce the known groundwater plumes originating from Alcoa's licensed activities, to protect the environmental values of Alcoa's site and the immediate surrounds. This plan is regularly adjusted in response to feedback from monitoring at key sites. Any losses from the residue areas are typically characterised by elevated total dissolved salts and elevated pH in the groundwater.

Alcoa currently maintains an integrated network of groundwater recovery bores at Kwinana to actively contain and control known groundwater plumes. The performance of the recovery bores is monitored and tracked against target recovery flows. Alcoa monitors the effectiveness of the recovery bore network using an extensive network of groundwater monitoring sites, and the results are reported to the regulators annually in accordance with licence conditions.

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

Prior to introduction of contaminated sites legislation groundwater monitoring identified elevated alkalinity in the retired and operating residue areas associated with older RSAs that were designed to the earlier specifications.

Elevated alkalinity was detected in groundwater in Areas A, B, C and F which constructed prior to 1972, were clay lined with a sand overlay. The liners were designed and built according to standards of the time but in places suffered deterioration from desiccation, cracking and rainwater erosion between the time of construction and the time of coverage by residue. Area H is the second oldest operating residue area, built in 1981. A small plume was identified in 2007 to the north of Area F, near the western dyke of Area H.

In line with the requirements of the Contaminated Sites Act 2003 which came into effect on 1 December 2006, Alcoa reported the retired and operating residue sites together with affected properties to the regulator for classification in 2007. Both areas were classified as Contaminated – Remediation Required due to seepage from the RSAs. Alcoa manages the related properties in line with the requirements of the Contaminated Sites Act 2003. Alcoa provides updates to stakeholders on the groundwater management programs through consultation processes such as the Kwinana Refinery EIP, and the Kwinana Refinery LTRMS SRG.

Since 2007, where monitoring has identified potential concerns, properties north of the retired residue area and west of the operating residue area have been reported to the regulator for classification. Where required these have been classified as Possibly contaminated - investigation required" or "Remediated for restricted use

Retired Residue Area

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

Groundwater in this area moves in a general north westerly direction. In addition to monitor bores there are recovery bores positioned to the north of Area A, to actively control and contain this plume.

Operating Residue Area

Alkali concentration identified within the operating residue footprint is managed by recovery bore networks. The groundwater flows from the east to the west and boundary monitoring bores monitor the risks at the perimeter of the operating residue area and potential risks posed to neighbouring downstream properties.

7.9.3 Groundwater Monitoring

Kwinana has a comprehensive and extensive groundwater monitoring network and monitoring program. The primary objective of the Groundwater Monitoring Program is to assess the effectiveness of the groundwater management activities and to determine if changes to the groundwater management plan are required. More specifically this includes:

- Ensuring that groundwater quality is continuously monitored enabling identification of potential risks to environmental values;
- Assessing water quality effects and determine if water quality is changing over time;
- Monitoring the quality of the groundwater entering Alcoa's property; and
- Assessing the effectiveness of the management plan, monitoring and recovery systems.

The routine monitoring for water quality at Kwinana has included use of down-hole logging to obtain pH and EC measurement at depth intervals, since 1979. The current program covers the refinery, retired and operational residue areas and consists of internal, perimeter and regional bores.

7.9.4 Guiding Principles and Alcoa's Response

In response to the information provided, the Kwinana LTRMS SRG developed one guiding principle relating to Groundwater presented below, together with Alcoa's response.

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	Water	
11	Alcoa to minimise impacts to groundwater and make groundwater monitoring results available.	Alcoa will continue to monitor and manage groundwater to minimise risks and report results in accordance with regulatory requirements.

7.10 Land Use Management and Visual Amenity

7.10.1 Background

Due to the terrain surrounding the Kwinana residue area and the volume of residue to be stored, the residue impoundments are a prominent feature on the local landscape. As population densities have increased in the immediate surrounds and with transport routes such as the Kwinana Freeway to the east, visual amenity became increasingly important. The Kwinana Residue SRG raised visual amenity as an important aspect in ongoing residue management.

7.10.2 Current Management Strategies

A land management program at Kwinana refinery has been ongoing for more than 20 years. The focus of Alcoa's visual amenity efforts is on the rehabilitation of external residue embankments which are increasingly visible as the height of the residue storage areas increases.

7.11 Residue Area Rehabilitation

7.11.1 Background

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

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

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

7.11.2 Current Management Strategies

The current focus of the revegetation work undertaken at the Kwinana residue area is on external embankments (external embankments are embankments on the boundary of the residue footprint which are unlikely to be disturbed in the medium term). Outer embankments are commonly constructed using residue sand, produced after separation of the sand from the residue mud. 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 prior to preparation for planting.

Kwinana's current revegetation program for residue areas uses native species that are typically found on limestone outcrops and in coastal heath lands. Stages 1 – 4 of the process are shown in Figure 7-3.

- **Stage 1:** The incorporation of gypsum alters the properties of residue to better reflect those of coastal sandy soils common to the Swan Coastal Plain of Western Australia.
- **Stage 2:** To provide a supply of plant nutrients at the time of planting, a custom blend of fertiliser is applied.
- **Stage 3:** A mix of native seeds is broadcast over the area, a layer of coarse wood mulch is subsequently applied to prevent the generation of dust from the bare surface before plant cover has been established.
- **Stage 4:** The final step in revegetation operations is the hand planting of tree, shrub and groundcover seedlings. These species are those that do not readily germinate from seed.

The native species used are adapted to the local climatic conditions and, draw the water they need from the residue sand profile. Water extraction by the plants will assist in reducing the total volume of water that will eventually need to be treated prior to release or reuse at closure.

Stage 1:

Gypsum incorporation
Gypsum for soil improvement (225 t/ha to 1.5m depth)

Stage 2:

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

Stage 3:

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

Stage 4:

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

Figure 7-3: Typical Residue Rehabilitation Process

7.11.3 Rehabilitation Guiding Principles and Alcoa's Response

In response to the information provided, the Kwinana LTRMS SRG developed guiding principles relating to residue rehabilitation. These are presented below, together with Alcoa's response.

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Rehabilitation and Closure**	
15	Alcoa to consider progressive rehabilitation and closure of RSAs.	Alcoa currently undertakes progressive embankment rehabilitation and considers opportunities for the closure of RSAs as part of its long-term planning activities.
16	Alcoa to ensure appropriate funding is provisioned for rehabilitation, closure and ongoing monitoring.	Alcoa recognises its liability for rehabilitation of the residue areas and will continue to maintain a financial provision for this rehabilitation.
19	Alcoa to consider alternative shrubs to "golden wattle" due to impact on surrounding areas.	Alcoa regularly reviews the species used in its residue rehabilitation prescription which is based on coastal dune species. Some yellow flowering Acacia species are included in the prescription as they play a vital role in the establishment of a vegetation cover on the rehabilitated sites. *Acacia pycnantha,* most commonly known as the "golden wattle", is not used in the current residue rehabilitation prescription.
21	The visual amenity of the RSAs is a priority for the community members of the SRG.	Alcoa acknowledges that visual amenity of the residue area is a priority for the community. This LTRMS document includes information regarding visual amenity.

8 Future Residue Development Strategies

8.1 Residue Planning and Design Framework

Alcoa is in the process of updating the comprehensive residue management plan for the medium term (2024-2034) and life of the current mining lease (2045) and finalising the short-term residue management plan for 2020-2024. These planning processes consider the guidance provided through the LTRMS SRG process. Mud drying, dyke construction, planned maintenance and other sustaining activities are carried out in accordance with a detailed annual program of work, which is developed within the context of the short-term residue management plan.

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

8.2 Constraints on Forward Planning of Residue Operations

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

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

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

This LTRMS identifies the:

- current projected residue footprint for 2020-2024;
- current proposed area over which the residue area may expand during the mid-term 2024-2034; and
- current preferred area over which the residue area may expand during the life of the current mining lease (2045).

8.3 Future Residue Planning

Alcoa's future residue planning work is focussed on two key streams of work that are progressed in parallel:

- Research to identify mechanisms to reduce the area required for future residue storage; and
- 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 these key areas:

- Alternative uses for residue.
- Reducing required drying area/time.
- Bauxite residue filtration equipment improvements and capacity.
- Alternative storage technologies and processes.

Alternative Uses for Residue

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

Reducing Required Drying Area and Time

Alcoa's uses a drying model formula to assist in its residue planning. This formula helps Alcoa to determine the drying area required for the mud drying beds 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 of new residue area development. Alcoa modified its operations post trialling alternative amphirolling cycles and the use of flocculants to assist with residue dewatering. The flocculant trialled did not demonstrate any significant reduction in drying time.

Alternative Storage Technologies and Processes

Following consultation and the LTRMS Kwinana 2013 Partial Review, Alcoa commissioned residue filtration at the Kwinana refinery in 2017 A similar facility has since been installed at the Pinjarra Refinery.

The filter presses essentially work by forcing the moisture out of the residue, leaving behind a low moisture solid filter cake. Filtration has several advantages:

- Residue operations could be sustained within the current available footprint;
- Residue water use is significantly reduced;
- Reduced potential to produce dust from the drying areas; and
- Reduced potential to impact groundwater.

No guiding principles were developed by the Kwinana LTRMS SRG relating to Residue Storage Techniques.

8.4 Residue Area Planning Considerations

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

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

As the mud elevation in drying areas increases over time, perimeter embankments progressively move inwards, and the net available drying area reduces. Consequently, to maintain the minimum drying area required to dry mud, it is necessary to periodically construct new drying areas. Alcoa uses several principles in its planning processes for new residue areas. These include greenfield site assessment, footprint development direction, residue stack heights, dam break assessments and proximity to neighbours.

Whilst the introduction of filtration provides benefits in reducing drying times and slowing the rate of expansion of the residue footprint, the need for all methods of storage: emergency bypass slurry deposition, solar drying of the mud and spreading of residue filter cake, all remain part of the operations.

8.4.1 Greenfield Site Assessment

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

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

ECONOMIC	ENVIRONMENTAL	SOCIAL
Cost of construction (pumping, piping, infrastructure relocation). Associated costs such as relocation of key infrastructure such as powerlines and water pipelines.	Potential impact on protected species and ecologically sensitive areas. Potential dust and odour impacts. Ground water levels. Ability to achieve necessary approvals.	Potential impact on any heritage sites (Aboriginal and European). Visual amenity impacts. Potential impact on neighbours.

8.4.2 Development Direction

Alcoa's options for residue storage area expansion at Kwinana is affected by land availability and the need for adequate separation distances which consider impoundment safety, environmental and amenity requirements.

Alcoa's operations are best supported by planning outcomes which seek to minimise the potential for land use conflicts.

Alcoa's operations are best supported by an industrial interface consistent with the State's Planning Policy framework and established buffers including: the 1km Kwinana Air Quality buffer zone; and 1 – 1.5km transitional zone.

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

Northern expansion

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

Southern expansion

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

Water storage is considered a temporary land use as when the refinery closes, the water storage ponds can be fully decommissioned, and the land can then be made available for other uses. Relocation of the water storage ponds outside of the existing residue footprint may facilitate the consolidation of the existing residue area footprint.

Alcoa believes that the potential impacts from new water storage activities/ areas can be effectively managed.

Western expansion

Expansion of the current residue area to the west whilst an option, is limited by wetlands, Abercrombie Road and a major gas pipeline. Residue footprint expansion westwards is also constrained by industrial development in Latitude 32 and the Flinders Precinct and limited land options.

Eastern expansion

Alcoa does not consider expansion of the current residue areas to the east within the Kwinana Air Quality Buffer as a preferable option due to the proximity of neighbours and the location of the Bush Forever site. An area of Mandogalup within a kilometre of the residue areas is currently subject to the State Government's Improvement Plan 47 (IP47) process.

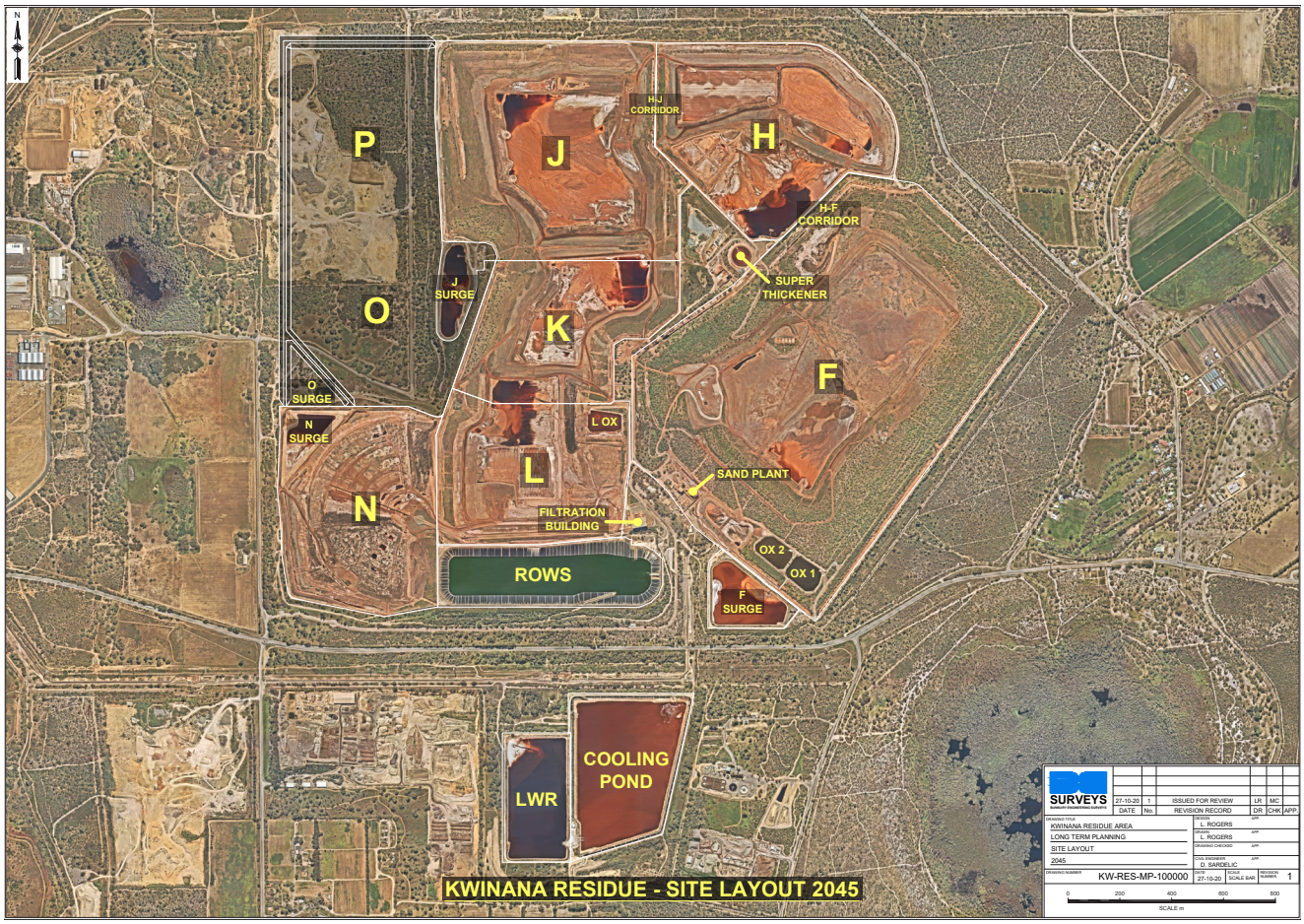

Figure 8-1: Indicative operating residue area footprint in 2045

The IP47 Process seeks to establish the strategic planning and development intent within the IP47 area, including the preparation of an improvement scheme. Alcoa and the SRG agree that this is an important process to provide clarity and certainty for Alcoa, landowners and developers.

Alcoa operations are best supported by planning outcomes which minimise the potential for land use conflicts and are aligned with the boundaries defined by the Kwinana Air Quality Buffer.

North West expansion

In considering future residue expansion options, Alcoa have previously considered a site currently occupied by a quarry as a potential option for the relocation of water storage facilities to the North West.

8.4.3 Residue Land Use

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

- a lower risk of groundwater contamination from residue areas;
- a reduction in contaminated run-off water requiring treatment and discharge after refinery closure;
- less surface area requiring rehabilitation;
- better definition of land separation requirements between residue and neighbouring properties; and
- reduction in the overall land area which may have long term planning constraints.

Other factors that affect the final footprint that need to be considered in stack design include structural stability, visual amenity, dust potential and the open surface area required for the drying cycle. The ultimate land area under residue storage will be affected by:

- the volume of residue requiring storage;
- the rate at which residue is produced;
- the residue drying treatment utilised;
- the way the residue stack is constructed;
- the viability of alternative uses for residue; and
- the availability of land.

Alcoa's options for residue storage area expansion at Kwinana is affected by land availability and the need for adequate separation distances which consider impoundment safety, environmental and amenity requirements.

To minimise the footprint, the design of the residue stack is optimised wherever possible to ensure the most efficient use of land. Residue filtration reduces the active solar drying area requirements for residue mud and related rate of footprint development. Other opportunities to minimise the footprint are sought through research into commercially viable residue reuse options.

8.5 Life-of-Mine Construction Strategy (2045)

Alcoa's current life of mine plans post filtration are to remain within the current footprint including the future residue storage areas O and P. No additional land for water storage is currently anticipated. Figure 8-1 shows the indicative operating residue area footprint in 2045.

Current plans indicate that the ROWS pond is not likely to be relocated, however Alcoa may consider conversion of the existing ROWS pond to residue storage, providing approximately 20 hectares of drying area in future. If this is the case Alcoa would need to acquire and rezone appropriate land for new water storage facilities.

Alcoa currently has enough appropriately zoned land to provide storage areas for the life-of-mine, at current planned production rates.

Future options not in the current plan which Alcoa may pursue include:

- relocation of the Super Thickener and associated infrastructure, and conversion of the area to dry storage;
- relocation of the current ROWS pond and construction of new water storage facilities to replace the existing ROWS pond.

8.6 Mid-Term Construction Strategy (2024-2034)

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

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

As the mud elevation in drying areas increases over time, perimeter embankments progressively move inwards, and the net available drying area reduces. Consequently, to maintain the minimum drying area required to dry mud it is necessary to periodically construct new drying areas. Projects designed to provide the drying area required are currently planned to be constructed to the north west of the operating residue area in land procured for this purpose zoned Rural B. Denoted as Areas O and P, in Figure 8-1.

Alcoa's application to rezone the land required for Areas O and P was approved on 29 March 2011.

- Construction of RSA O and associated surge pond.
    - The storm surge storage capacity for the Area O project originally included capacity to contain storm surge from the existing Area N. As Area N has a surge pond completely contained within the original Area N dam, surge capacity will only be required for Area O.
- Construction of RSA P.

8.7 Short-Term Construction Strategy (2020-2024)

Alcoa's focus for the mid-term strategy is to consolidate the existing residue area to make more efficient use of the drying area. The mid-term residue construction activities planned to achieve this include:

- RSA H conversion: complete conversion of the wet storage Residue Storage Area H to residue mud and sand storage. – This work is in line with the 2012 LTRMS plans to convert Area H from wet storage to solar drying. Since 2012, Area H has been partially converted to residue storage. The partial conversion already completed and the planned conversion of the remainder of this wet storage area optimises the use of the current footprint.
- RSA H Surge Pond: Conversion of Residue Storage Area H to solar drying prompted the proposal for the Area H Surge Pond. Subsequent project review in 2020 identified the opportunity to achieve the same outcomes by deleting the proposed Residue Storage Area H Surge Pond and replacing with a tank and pumping system.
- RSA H-J corridor conversion.
- RSA-F corridor conversion.
- Cooling Pond Spillway: caters for safe discharge of rainfall in a low likelihood extreme weather events. Spillways are required to ensure safe management of rainfall events which exceed the water containment design criteria to prevent overtopping and reduce the risk of embankment failure during extreme rainfall events as defined by the mandated Alcoa Impoundment standards which references The Austrialian Council of large Dams (ANCOLD) guidelines. This spillway has been installed in 2020.
- Ongoing operation of Residue Storage Area F, which includes residue storage and the other infrastructure related to operations located in this area, including the oxalate ponds, landfills cells drainage and groundwater systems; and
- Relocation of infrastructure, as required, to support the above projects.

8.7.1 Business as Usual

Construction Activities

The introduction of residue filtration has changed the management of the residue areas. Residue is either stored as filter cake from filtration or solar dried via the traditional solar drying and slurry bypass methods. The following 'business as usual' construction activities are carried out.

- For traditional residue solar drying and sand storage areas:
  - 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 from a 72 hour 1:100 year storm event;
  - construction and/or relocation of infrastructure associated with the embankment lifts;
  - construction of new underdrainage systems associated with new embankment walls and/or stockpiles;
  - installation of new decant structures, and/or relocation of existing decant structures, and associated pipe work and drainage; extension of sprinkler risers; and
- For bauxite residue filter cake spreading and stacking:
  - periodic relocation and/or raising of the conveyor system, spreader and stacker to maintain the freeboard necessary to

Figure 8-2: Cooling Pond Spillway

support filter cake deposition and spreading activities

- optimising the filtration equipment performance
- construction and/or relocation of infrastructure associated with the area as the area is built
- construction of new underdrainage systems associated with these areas;
- installation of new decant structures, and/or relocation of existing decant structures, and associated pipe work and drainage; and
- Application of dust suppressants.

- General:
  - construction of new roads;
  - extension/modification of the groundwater bore monitoring network;
  - extension/modification of mud and sand distribution pipe work; and
  - general maintenance activities which involve construction activities.

Several techniques are used to raise embankments. Where practical and cost effective, the preferred method is to construct the embankments using hydraulically placed residue sand.

However, it is sometimes necessary to construct residue sand embankments using mechanical placement techniques (e.g. using scrapers, dump trucks and rollers) and/or raise embankments using mud sourced from the drying areas whereby mechanical placement and compaction techniques are again necessary.

Filtered residue or 'Filter cake' is placed using either a mobile spreader and stacking unit combined with mechanical spreading and compaction or by mechanical placement, spreading and compaction. These areas are typically mulched.

8.7.2 Area F

Residue Storage Area (RSA) F which supports storage and other residue operations is one of several areas which form the operating residue storage area and remains a required part of the ongoing operations.

As outlined in the 2005 Kwinana LTRMS document, Alcoa intended to implement plans to close and rehabilitate RSA F. Progress towards this goal had been made by the time of the 2012 LTRMS.

Whilst it was previously considered that for RSA F to be closed, RSA O and its associated Surge Pond needed to be constructed and commissioned prior to ensure the required drying area for Kwinana Refinery, this is no longer the case. Since the installation of filtration Alcoa has identified the need for retention of RSA F for effective footprint management to support the ongoing operating residue requirements and rotation of the filtered mud and solar drying areas.

RSA F, used for contingency, is required to remain an active part of the operational residue area for the foreseeable future. RSA F together with other infrastructure associated with RSA F and other operations located in this area, such as water and drainage management systems, recovery systems, landfills cells and oxalate storage need to remain operational for the life of the facility.

Alcoa presented this requirement at the 2019 SRG meetings and Alcoa acknowledges that closure of RSA F is a priority for community members.

The Addendum captures the LTRMS strategy update provided to the LTRMS SRG in July 2021 which outlined the decision to use Area F on an ongoing basis.

Figure 8-3: Bauxite Residue Filtration Bypass Emergency Stacker

8.7.3 Residue Area Development Guiding Principles and Alcoa's Response

In response to the information provided, the Kwinana LTRMS SRG developed three guiding principle relating to Residue Area Development.

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Residue Area Development**	
7	Alcoa to continuously improve residue area design, construction, operations and closure planning to industry best practice in consultation with key stakeholders.	Alcoa Global Impoundment Standards reference the Australian National Committee on Large Dams (ANCOLD) Guidelines in the development of protocols for the design, construction, operation and closure of residue storage areas. Alcoa will continue to consult with key stakeholders about its residue operations through existing stakeholder engagement processes.
8	The SRG supports the optimisation of the filtration facility and residue storage areas and westward expansion.	Alcoa's current footprint development plans, outlined in this LTRMS, include: • optimising the residue filtration facility; • residue storage optimisation in existing storage areas; • westward expansion to Residue Storage Areas O and P. Construction plans for the new facilities, including timelines, are subject to change due to various factors including economic, operational, and regulatory impacts.
9	Closure of Area F by 2020 is a priority for the community members of the SRG.	Alcoa acknowledges that Closure of Residue Storage Area (RSA) F is a priority for community members. Residue Storage Area F which supports storage and other residue operations is one of several areas which form the operating residue storage area and remains a required part of the ongoing operations. The area will remain operational post 2020.

9 Residue Closure & Rehabilitation

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

The process of defining the closure strategy will be ongoing. Final closure of the Kwinana residue area is many years away, and available technology and community opinions regarding final land use may change over time.

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

- Have the capability to be used for productive community benefit;
- Be a safe and self-sustaining structure in the long term; and
- Allow future access to residue for alternate uses.

The *Alumina Refinery Agreement Act 1961*, clause 6(4) (d) states that "The Company shall use reasonable endeavours to ensure that each portion so filled will support buildings for light industry."

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

9.1 Closure Strategy Options

The rehabilitation of the residue deposits will be ongoing during the operating life of the refinery. The perimeter embankments are typically rehabilitated as the height of the stack grows, and revegetation of the surface of the drying beds will occur as each reaches its nominated final elevation. At the time of refinery closure, much of the rehabilitation will be complete with only the minimum drying area remaining to be closed.

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

9.1.1 Encapsulation

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

With this option, the leachable alkali remaining in the deposit at the time of closure would be encapsulated within the deposit. The surface runoff water may initially be alkaline due to the alkalinity of the surface residue sand layer. Continuous rainfall leaching of this surface sand layer would, over several years, reduce the alkalinity of the runoff to the point where no treatment would be necessary prior to release.

9.1.2 Continued Leaching

This option assumes that leaching of the deposit would continue beyond the operating life of the refinery. Seepage of rainfall through the residue stack would be encouraged, maximising the recovery of leachable alkali, while maintaining a low hydrostatic head on the base seal. As for the encapsulation option, it should be possible to release surface runoff water without treatment after several years of rainfall leaching of the residue sand capping layer. However, the water which passes through the stack and is collected via the internal drainage system would continue to leach alkalinity from the stack. This water is likely to require treatment for some further period of time if it is to be released to the environment.

9.2 Current Closure Strategy

Based upon current disposal technology and the experience Alcoa has gained over the past 50 years with bauxite residue management in Western Australia and other international Alcoa residue facilities, Alcoa 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 PVC liner at the base of the stack. Residue mud is then stacked, within the sand dykes which form the perimeter

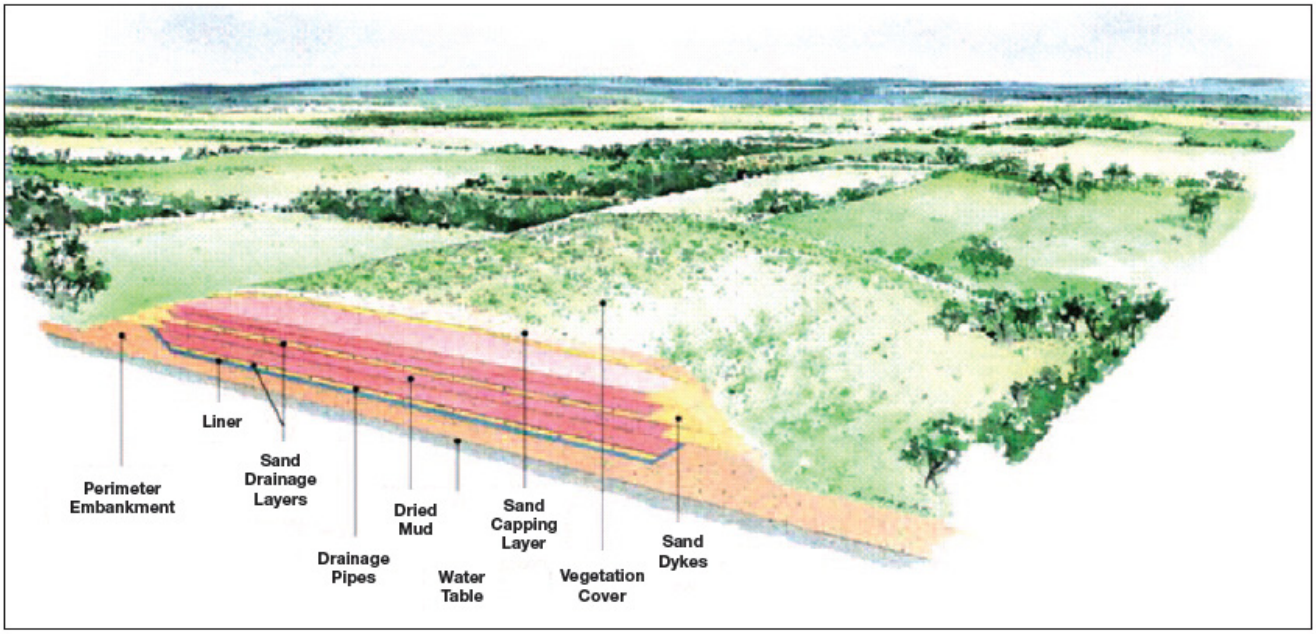

Figure 9-1: A schematic representation of a residue stack area at closure

embankments. Upon closure, the area is revegetated in a manner that meets the agreed future land use objectives for the site. This may include placing a sand capping layer over the stack prior to revegetation, which will assist in controlling wind and water erosion of the stack.

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

The advantages of this closure strategy include:

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

Ideally, decommissioned residue storage areas should have the capability to be used for productive community benefit. Currently, the residue rehabilitation research is focused on establishing a native vegetation cover utilising coastal dune species. We consider this to be appropriate as;

- it is self-sustaining once established;
- provides an aesthetic buffer to the landform; and
- can be readily adapted to other land uses (agriculture, industrial) at a future time if required.

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

9.3 Water Balance / Discharge Management

As the residue deposits are closed, a vegetated surface will be established. Both rainfall and liquor will continue to leach through the deposit and will be collected by the base drainage system as an alkaline leachate. These waters will need to be treated prior to release, or reuse through other industries, once the refinery has closed.

The volume of alkaline drainage water produced will depend on the water use of the established vegetation and the land area covered by residue. 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.

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

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

Further assessment of these options requires identification of background water quality parameters for potential receiving water bodies, a review of the pertinent standards relating to different water sources and their uses, assessment of the treatment options, cost implications and processes for discharge.

The benefits of successfully reducing the pH of the residue leachate will be recognised at closure when the level of treatment of waters prior to reuse, and the timeframe over which treatment is required, should have reduced. 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 & Revegetation

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

The current rehabilitation program is designed to maintain flexibility such that a range of final land uses can be considered. In this context, however, Alcoa notes the requirement under the Alumina Refinery Act that the land will ultimately be able to support buildings for light industry.

An example of final land use is the portion of Residue Storage Areas A, B, C which has been successfully redeveloped as the Perth Motorplex (Figure 9-2) which opened in December 2000.

In 1994, a section of closed drying area at the Pinjarra Refinery was established to demonstrate a range of possible 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 residue and results from the demonstration area.

Sheep and cattle have also been grazed on pastures on the demonstration area, and blood and tissue samples monitored routinely to identify any adverse effects on animal health of grazing residue areas. The results show that sheep and cattle grazed on residue areas maintain good health and do not develop marked mineral imbalances. There is also no evidence of heavy metal retention.

Alcoa's research considers the requirements for establishing a sustainable ecosystem on residue storage areas, whilst operating and closed. Current research is identifying ways to improve the characteristics of residue to make it more favourable to plant growth, to build on the current rehabilitation prescription.

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

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

At each review of the LTRMS the opportunities for future use will be reviewed with the community and strategies will be updated periodically unless replaced by Closure plans. This will ensure the options being investigated remain consistent with the needs of the community and Alcoa.

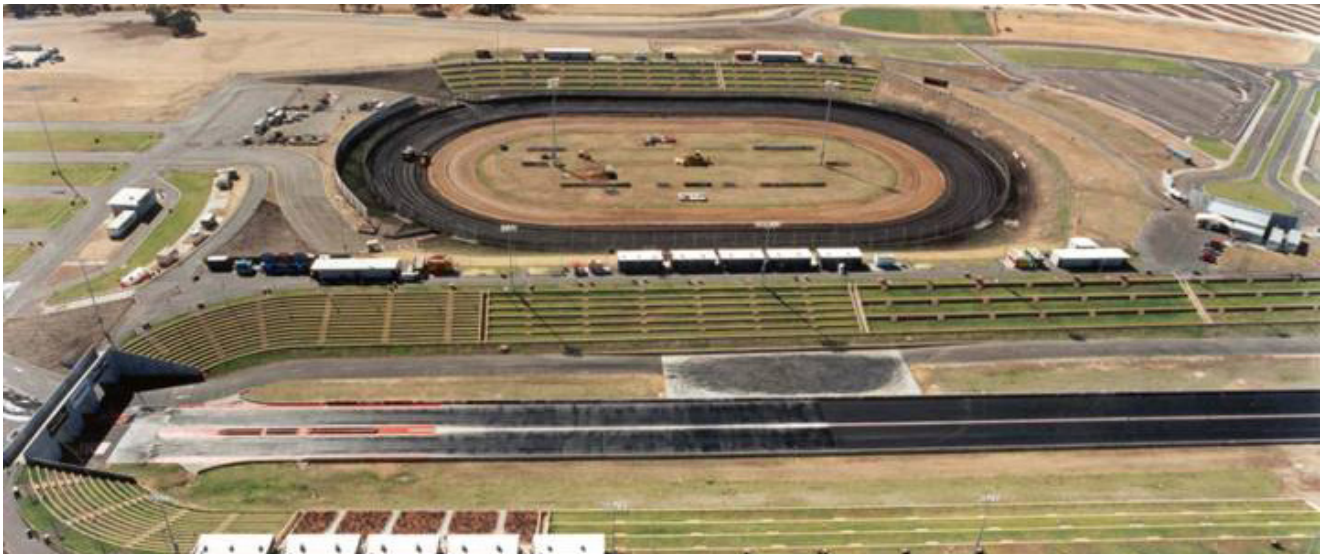

Figure 9-2: Perth Motor Sports Complex

9.5 Closure Funding

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

9.5.1 Closure Guiding Principles and Alcoa's Response

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

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Rehabilitation and Closure**	
17	Agreed completion criteria for closure are in place and complied with.	The process of defining the closure strategy and planning will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes may change. Alcoa recognises that future development of the closure strategy for the site requires consideration of completion criteria.
18	Alcoa to reiterate the future land uses previously articulated in the 2012 LTRMS. Alcoa to provide clarity in the LTRMS and information on potential future land uses to inform local and state government and legislative processes and guide Alcoa's current operations.	The process of defining the closure strategy and planning will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes may change. This LTRMS document includes information regarding future land uses. Alcoa continues to consult with stakeholders on issues relating to closure planning through the existing stakeholder engagement processes.
20	After closure, the water management system is passive, self sustaining and safe.	The process of defining the closure strategy will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes may change. Alcoa is currently developing and operating water management strategies at its residue locations to inform future closure plans.

10 Stakeholder Reference Group Guiding Principles

10.1 Summary of Guiding Principles and Alcoa's Response

The input from the community and stakeholders to this Kwinana LTRMS is summarised in the guiding principles developed by the SRG. As reflected throughout this document, the SRG participated in extensive discussion on residue management and planning issues, enabling them to develop informed guiding principles for consideration by Alcoa.

Table 10-1 summarises the guiding principles developed by the SRG and Alcoa's responses.

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 Response

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Dust Management**	
1	Alcoa acknowledges that dust management is important to the SRG and commits to ongoing communication regarding dust management and responsiveness to community comments.	Alcoa acknowledges dust management is important to the stakeholders. Alcoa will continue to communicate dust management performance through existing stakeholder engagement processes and other relevant communication and feedback processes.
2	Alcoa to use best endeavours to contain emissions on site in accordance with relevant standards.	Alcoa regularly reviews its dust management processes and practices with the objective of continuously improving dust management at the residue areas. Alcoa will continue to monitor dust in accordance with environmental licence conditions.
3	Alcoa to continue to improve dust management including exploring new technology and best practice.	Alcoa regularly reviews its dust management processes and practices with the objective of continuously improving dust management at the residue areas.
4	Alcoa to consider the impact of climate change on residue dust management regarding unknown wind and weather patterns.	Alcoa works with weather forecasting providers to improve the accuracy of forecasts and adapts its short, medium and long-term dust management responses accordingly.
5	Alcoa to communicate to stakeholders its contingency plan for failure or inaction of current residue area dust management practices.	This LTRMS document includes information regarding Alcoa's dust management practices.
#	**Waste Management**	
6	Alcoa to consider suitable waste to go to Avertas Energy waste to energy plant.	Alcoa has a focus on reducing waste to landfill through recycling programs and waste minimisation efforts, including assessing the viability to use new facilities such as waste to energy plants e.g. Avertas Energy.

	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Residue Area Development**	
7	Alcoa to continuously improve residue area design, construction, operations and closure planning to industry best practice in consultation with key stakeholders.	Alcoa Global Impoundment Standards reference the Australian National Committee on Large Dams (ANCOLD) Guidelines in the development of protocols for the design, construction, operation and closure of residue storage areas. Alcoa will continue to consult with key stakeholders about its residue operations through existing stakeholder engagement processes.
8	The SRG supports the optimisation of the filtration facility and residue storage areas and westward expansion.	Alcoa's current footprint development plans, outlined in this LTRMS, include: • optimising the residue filtration facility; • residue storage optimisation in existing storage areas; • westward expansion to Residue Storage Areas O and P. Construction plans for the new facilities, including timelines, are subject to change due to various factors including economic, operational, and regulatory impacts.
9	Closure of Area F by 2020 is a priority for the community members of the SRG.	Alcoa acknowledges that Closure of Residue Storage Area (RSA) F is a priority for community members. Residue Storage Area F which supports storage and other residue operations is one of several areas which form the operating residue storage area and remains a required part of the ongoing operations. The area will remain operational post 2020.
#	**Water**	
10	Alcoa to continuously improve processing technology to reduce water requirements.	Alcoa will continue to focus on water efficiency by maximising water conservation and the use of recycled and fit for purpose water. Residue filtration has resulted in a reduction of water used in our operations.
11	Alcoa to minimise impacts to groundwater and make groundwater monitoring results available.	Alcoa will continue to monitor and manage groundwater to minimise risks and report results in accordance with regulatory requirements.
#	**Residue Reuse**	
12	Alcoa to continue to actively pursue safe alternative uses of residue.	Alcoa will continue to pursue safe, environmentally sustainable and viable alternative uses of residue. Each potential use will be assessed for feasibility on a case-by-case basis.
13	Alcoa to provide updates to stakeholders regarding the status of residue re-use projects, more regularly when progress made is material.	Alcoa will provide updates to stakeholders through the existing stakeholder engagement processes.
14	Alcoa to minimise impacts of residue reuse infrastructure and processing on surrounding areas, environment and neighbouring communities, including waste management, transport, noise, dust, odour; in accordance with approved licencing conditions.	Alcoa is currently studying the feasibility of the commercialisation of the Red Sand™ (washed and carbonated bauxite residue sand) product. If the production of the Red Sand™ is deemed feasible, environmental and social considerations will be factored into the Red Sand™ project.

#	GUIDING PRINCIPLE	ALCOA'S RESPONSE
#	**Rehabilitation and Closure**	
15	Alcoa to consider progressive rehabilitation and closure of RSAs.	Alcoa currently undertakes progressive embankment rehabilitation and considers opportunities for the closure of RSAs as part of its long-term planning activities.
16	Alcoa to ensure appropriate funding is provisioned for rehabilitation, closure and ongoing monitoring.	Alcoa recognises its liability for rehabilitation of the residue areas and will continue to maintain a financial provision for this rehabilitation.
17	Agreed completion criteria for closure are in place and complied with.	The process of defining the closure strategy and planning will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes may change. Alcoa recognises that future development of the closure strategy for the site requires consideration of completion criteria.
18	Alcoa to reiterate the future land uses previously articulated in the 2012 LTRMS. Alcoa to provide clarity in the LTRMS and information on potential future land uses to inform local and state government and legislative processes and guide Alcoa's current operations.	The process of defining the closure strategy and planning will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes may change. This LTRMS document includes information regarding future land uses. Alcoa continues to consult with stakeholders on issues relating to closure planning through the existing stakeholder engagement processes.
19	Alcoa to consider alternative shrubs to "golden wattle" due to impact on surrounding areas.	Alcoa regularly reviews the species used in its residue rehabilitation prescription which is based on coastal dune species. Some yellow flowering Acacia species are included in the prescription as they play a vital role in the establishment of a vegetation cover on the rehabilitated sites. *Acacia pycnantha*, most commonly known as the "golden wattle", is not used in the current residue rehabilitation prescription.
20	After closure, the water management system is passive, self sustaining and safe.	The process of defining the closure strategy will be ongoing, recognising that it will be many years before closure, and that available technology and community attitudes may change. Alcoa is currently developing and operating water management strategies at its residue locations to inform future closure plans.
21	The visual amenity of the RSAs is a priority for the community members of the SRG.	Alcoa acknowledges that visual amenity of the residue area is a priority for the community. This LTRMS document includes information regarding visual amenity.

Addendum

Purpose of addendum

This Addendum has been provided to capture an LTRMS strategy update provided in July 2021 and subsequent feedback from the SRG members and near neighbours.

Alcoa provided a written update to the LTRMS SRG and near neighbours on 12 July 2021. SRG members were also invited to an LTRMS update meeting on the 28 July 2021 at the Ken Jackman Hall, Kwinana.

LTRMS written update provided to SRG members and neighbours on 12 July 2021

As advised previously, from time to time we have been using the eastern residue storage area known as Area F, located north of Anketell Road, for sand storage and solar drying of our residue mud. Operational requirements have now prompted the need to use the area on a more frequent basis.

We acknowledge our historic intention to close and rehabilitate Area F and that this was identified as a priority by community stakeholders during recent consultation on our latest Long-Term Residue Management Strategy (LTRMS). However, as we stated during the 2019 LTRMS engagement process, that is no longer our intention and Area F remains an integral part of our ongoing operations.

That said, we are continuing our efforts to optimise our residue footprint including through the residue filtration technology that we introduced to the Kwinana refinery in 2016. This process removes water from residue, reducing the area required for solar drying. While the technology is working satisfactorily, it is still not at full capacity, which is a factor in the need to reintroduce regular solar drying to Area F. Improving the capacity of this technology remains a current key focus.

LTRMS update meeting with SRG members on 28 July 2021

Alcoa invited all 17 external SRG members to a follow up LTRMS update meeting on 28 July 2021 at the Ken Jackman Hall, Kwinana. Fourteen SRG members or their proxies and four Alcoa employees attended. The meeting covered the communication from 12 July 2021 regarding more frequent use of Area F and other short and mid-term strategy updates. In respect to the mid-term strategy (2024-2034), SGR members were informed that updated survey work for approvals for proposed residue storage areas O and P were being progressed in 2021. In respect to the short-term strategy (2020-2024), Alcoa confirmed the completion of the Cooling Pond Spillway and that the proposed H Surge Pond had been replaced by a tank and pumping system since the 2019 SRG meetings.

Summary of community, neighbour and SRG member feedback and Alcoa's response

Alcoa would like to thank all respondents for taking the time to review the LTRMS and provide feedback on the draft report and subsequent updates. Alcoa received 22 submissions: 10 from SRG members; 2 from direct relatives of SRG members; 5 from a family of joint executors who do not live on the property; 4 from neighbours; and 1 from a landholder who does not live on the property. The table below provides a synopsis of queries or positions raised by stakeholders post review of the draft LTRMS document and the LTRMS update information and session.

SUMMARISED NEAR NEIGHBOUR AND SRG MEMBER FEEDBACK	ALCOA RESPONSE
Some neighbours highlighted the history of their or their family's land tenure in the adjacent rural Mandogalup area. • Some noted their family tenure predated the development of the current Alcoa operating residue area.	• Alcoa acknowledges and respects there are families who have been living in the area prior to and during the development of the Alcoa residue storage area.
• Some respondents acknowledged the amicable co-existence of the rural landholders with the Alcoa operations for many of the past 50 years.	• Alcoa agrees there is a history of amicable coexistence with landholders.
• Some respondents shared their understanding of the history of Alcoa's operations and various Government planning processes and policies.	• Alcoa acknowledges and respects the respondents' perspective on the history of Alcoa's operations and the Government planning processes and policies.

SUMMARISED NEAR NEIGHBOUR AND SRG MEMBER FEEDBACK	ALCOA RESPONSE
• Some SRG community members reiterated their desire for Area F to be closed and felt aggrieved by the change in strategy regarding Area F, which Alcoa had proposed in 2005 to close by 2011.	• Alcoa acknowledges the 2005 intent to close Area F, which was contingent on a number of factors detailed in the 2012 LTRMS and addressed during this LTRMS stakeholder engagement process. Refer to LTRMS section 8.7.2 Area F.
• Some respondents stated that the draft LTRMS failed to acknowledge that previous LTRMSs had flagged the closure of Area F.	• This is not the case. LTRMS section 8.7.2 covers the historic intent to close Area F.
• One respondent noted that if Area F had reached its maximum capacity, Alcoa should maintain its commitment to close it.	• Area F has not reached its maximum capacity.
• Some respondents objected to the continued use of Area F claiming it was deliberate strategy by Alcoa to prevent rezoning of land to residential.	• This is not the case. The requirement for Area F to remain part of Alcoa's operational area has been set out in the response to Guiding Principle 9, which was communicated with the LTRMS SRG in 2019.
• Many respondents indicated planning restrictions on their land limited their options, which was stressful, particularly for those nearing retirement. o Some suggested these restrictions linked to the City of Kwinana's June 2018 Local Planning Policy 12 *Mandogalup Future Development* and Local Planning Scheme 2. o Others attributed the restrictions to the buffer. o One respondent confirmed improvements had been approved and constructed on land in the area. The timing of these improvements was not provided, so may predate the restrictions referenced.	• Alcoa is not able to comment on planning restrictions as this is a matter for the landowner and the relevant authority.
• Some respondents indicated their preference for future residential zoning rather than light industrial. • Some landowners questioned the need for a buffer supported by industry to resolve conflicting land uses.	• Zoning is a matter for the Western Australian Planning Commission (WAPC) Improvement Plan 47 – Mandogalup processes not the LTRMS. • Alcoa understands the respondents' preference and accept that Company and landowner's opinions on land zoning and buffers may differ.
• Some respondents shared their understanding of the history and status of the buffer and related dust studies and EPA advice. Different opinions were presented on the basis for the buffer and its status.	• Alcoa understands the respondents' position with respect to their land ownership or property interests within the buffer that is referenced in Section 2.2 of the November 2018 Western Australian Planning Commission (WAPC) Improvement Plan 47 – Mandogalup. • Alcoa has been transparent on the Company's support of the Kwinana Industrial Air Quality Buffer since its inception.
• Some respondents highlighted an expectation for Alcoa to contain emissions and amenity impacts on site.	• This expectation, and Alcoa's response to it, is captured in LTRMS Guiding Principle 2.

SUMMARISED NEAR NEIGHBOUR AND SRG MEMBER FEEDBACK	ALCOA RESPONSE
• Some respondents raised concerns regarding the continued operation of Area F impacting on visual amenity, property values, and the surrounding environment.	• Alcoa has a Global Impoundment Policy that provides direction for the management and governance of our residue storage areas in accordance with regulatory requirements, industry guidelines and international standards. • The geometry of Area F's stack design (embankments and internal dyke slopes) is influenced by structural stability and visual amenity requirements. • Visual amenity is addressed in the Guiding Principle 21 and Section 7.10 of the LTRMS.
• Two respondents raised concerns regarding the need for a buffer in the context of mitigation for an embankment failure and noted that this should be concerning for regulators. • Another respondent suggested closure of Area F would mitigate embankment failure.	• While the buffer was developed in the context of environmental dust and amenity, it does provide a safeguard mechanism should a low likelihood high consequence event such as an embankment failure eventuate. • Alcoa is aligned with other global entities who seek to maintain appropriate buffers around residue storage areas by supporting compatible land use planning to reduce populations at risk should a low likelihood, high consequence embankment failure ever eventuate. LTRMS Section 4.3. • Embankment failure considerations apply to operating and closed residue facilities.
• Some respondents believed it was not possible to sell their rural properties, and/or their property values had been detrimentally impacted due to Alcoa's operations and/or the buffer.	• Property market evidence in recent year suggests property is saleable. • Alcoa's operations have not precluded activities undertaken on neighbouring rural landholdings nor land sales.
• Some respondents said their property purchases in the area (recent and historical) had been influenced by future zoning expectations and expressed annoyance with Alcoa.	• Alcoa cannot account for landowners' decisions taken in respect of potential planning outcomes.
• Some respondents suggested that if Alcoa proposed to continue its operations it should offer to purchase their land.	• Alcoa's operations have not precluded continuity of any of the existing rural land uses nor land sales. • Alcoa is supportive of compatible land use planning.
• Several respondents expressed a view that the residue storage areas should be relocated with proposals ranging from removal from the urban area, to the rehabilitation of Area F, to a move westwards.	• Alcoa's Kwinana Alumina Refinery has operated in the Kwinana Industrial Area for more than 50 years. Operations were originally adjacent to rural zoned land. Alcoa agrees more recent urban expansion has created a need for responsible land use planning to resolve potential conflicts. • Alcoa has sought to support community preference for westward expansion with future residue storage areas planned to the west. • Area F will continue to be in use due to operational requirements.
• A query was raised regarding the future use of proposed residue storage areas (Areas O and P).	• Alcoa confirms works are underway in preparation for the future residue storage area including limestone recovery.
• Some respondents challenged whether Alcoa had lost its social and environmental licence to operate.	• Alcoa understands and values the importance of maintaining both its regulatory and social licence to operate. • Alcoa has an extensive stakeholder and community engagement and consultation process that includes this voluntary LTRMS process. • Alcoa operations are supported by the State Agreement Acts and Environmental Licences.

SUMMARISED NEAR NEIGHBOUR AND SRG MEMBER FEEDBACK	ALCOA RESPONSE
• Four of the five community members on the LTRMS SRG withdrew consent for their photograph and names to be used in the report.	• Alcoa respects the community members' request and has redacted the participants' names and the SRG photograph from the report.
• Some LTRMS community stakeholders re-submitted a statement first provided to Alcoa in 2019, presenting their views on the validity of the buffer; the desire for closure of Area F; concerns about potential future uses of Area F indicating their preference for open space not industry post closure; voiced concerns about planning processes and the impartiality of various industry and government stakeholders; and objected to the use of Area F.	• Community stakeholders' views regarding the importance of closing Area F are captured in Guiding Principle 9. • Future uses of any residue storage area post closure need to conform with the requirement stated in Section 9 of the LTRMS.
• Some SRG community members challenged the validity of the facilitated 2019 LTRMS consultation. • Some felt their input and advice had been ignored. • Concerns were raised by another participant regarding the time allowed to develop guiding principles; input not being considered; and the inability to reach group consensus on all the guiding principles because of members' divergent views.	• The LTRMS SRG meetings were convened by an independent facilitator with nearly 30 years of experience in stakeholder engagement. • The Guiding Principles outlined in Section 10 reflect the consolidation of the SRG feedback. • The independently facilitated process allowed time for the SRG to workshop as groups and capture their feedback in the 21 Guiding Principles, which the SRG formulated. • Alcoa recognises the Company's strategic direction shared through the LTRMS is not fully aligned with neighbours views. However, the inclusion of the Guiding Principle 9 for Area F, despite not being endorsed by all SRG members, is representative of the inclusive approach taken during this voluntary engagement process.
• Some respondents commented that Alcoa had not consulted adequately on its plans for Area F.	• This LTRMS process and previous LTRMS processes have included engagement with stakeholders on Area F and the recent updates have been shared with the SRG and neighbours. • The LTRMS, once finalised, will be made available publicly in line with the previously published LTRMS documents. The LTRMS process has included opportunity for neighbours to provide feedback on the draft LTRMS and the 2021 update.
• One respondent noted that the State Government, residents, EPA and property developers had been working collaboratively to gain certainty over land use for a long time. • The same respondent suggested Alcoa had incorrectly boycotted the EPA's plan to replace the buffer with suitable land use scenarios, which were currently being investigated by the WA Planning Commission in the IP47 process.	• The current Western Australian Planning Commission Improvement Plan 47 Mandogalup (IP47) website notes the process involves stakeholder engagement with landowners, local government, industry and peak bodies. • Alcoa has not boycotted the independent IP47 government process. Alcoa is one of many stakeholders with an interest in the IP47 process.

SUMMARISED NEAR NEIGHBOUR AND SRG MEMBER FEEDBACK	ALCOA RESPONSE

• One respondent stated: "The focus of the LTRMS is on extending the current Kwinana Environmental Protection Policy Buffer (EPP buffer) with the express purpose of restricting residential use and development in Mandogalup and removing any restrictions and limitations on Alcoa's operations".
• The primary concern raised was that the current and future operations of the residue areas:
  • Were compatible with existing residential uses and land currently zoned urban for future residential use east of the residue areas in Mandogalup;
  • Would not prejudice the option of the long-term use of the balance of the land in Mandogalup, east of the residue areas, for residential and associated uses.
	• Alcoa's State Agreement, the *Alumina Refinery Agreement Act 1961 (WA)* and the bauxite mining lease 1SA (2045) allows Alcoa to operate the residue storage areas until at least 2045.
	• It is Alcoa's view that, consistent with State planning policies, land use planning adjacent to its residue storage area operations should give proper consideration to this industrial interface and environmental buffers relevant to the land use.
	• Alcoa has been consistent in its support for the EPA-endorsed Kwinana Air Quality Buffer, which has maintained a level of separation between the residue storage areas and urban development. Alcoa opposed the decision to accommodate urban zoned land within the 1-1.5-kilometre buffer transition zone to the East and North.

• Some respondents referenced matters or raised planning queries related to the Western Australian Planning Commission Improvement Plan 47 Mandogalup (IP47) planning process and other recent urban development proposals north and east of Alcoa's operations. They raised concerns that Alcoa's operations may impact on these and future developments.	• Alcoa's Kwinana Alumina Refinery has operated in the Kwinana Industrial Area for more than 50 years. Operations were originally located adjacent to rural land, which includes rural zoned land within the Mandogalup IP47 Area. • WAPC's role is to ensure all land uses proposed in the Improvement Plan are consistent with State Planning Policy and the orderly and proper planning of the locality. It is Alcoa's view that land use planning adjacent to its residue storage area operations should give proper consideration to buffer requirements in relation to nature of the operation and proposed land uses.

LTRMS - future

Alcoa's voluntary LTRMS process has sought to consult with and provide information to stakeholders – including government, industry, landowners, and community members – on its operations and, where possible, seek alignment or mutual understanding where positions may differ.

The LTRMS information, while supportive of Alcoa and government planning processes, is part of an evolving planning continuum and subject to change. The LTRMS process seeks to provide information on Alcoa's forward planning direction at a particular point in time.

Alcoa is reviewing its LTRMS consultation processes in the context the new Global Industry Standard on Tailings Management (GISTM) and regulatory requirements.

Document updates

In addition to this summary of feedback on the draft LTRMS and associated updates, some minor edits and amendments proposed by respondents were accepted and included in this revised draft LTRMS.

Glossary

ANCOLD	The Australian National Committee on Large Dams
BMP	Best Management Practice
CCN	Community Consultative Network
CER	Consultative Environmental Review
CIF	Communities and Industries Forum
CPT	Cone Penetrometer Testing
DBCA	Department of Biodiversity, Conservation and Attractions
Development WA	Previously known as LandCorp
DIA	Department of Indigenous Affairs
DoE	Department of Environment (now the Department of Water and Environmental Regulation)
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EIP	Environmental Improvement Plan
EPA	Environmental Protection Authority
EPP	Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999
GHD	An engineering, architecture and environmental consulting company.
GLC	Ground Level Concentration
HDPE	High Density Polyethylene
HI	Hazard Index
HRA	Health Risk Assessment
ICOLD	International Commission on Large Dams
ICMM	International Council on Mining and Metals
IP 47	Improvement Plan 47 Mandogalup
KIA	Kwinana Industrial Area
KIC	Kwinana Industries Council
LTRMS	Long Term Residue Management Strategy
MRS	Metropolitan Region Scheme
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measures
NORM	Naturally Occurring Radioactive Material
$PM_{2.5}$	Particulate Matter less than 2.5 µm in diameter
PM_{10}	Particulate Matter less than 10 µm in diameter
PVC	Polyvinyl Chloride
ROWS	Run Off Water Storage
RPLG	Residue Planning Liaison Group
RSA	Residue Storage Area
SKM	Sinclair Knight Merz. A strategic consulting, engineering and project delivery company.
SMPSPF	South Metropolitan Peel SubRegional Planning Framework
SRG	Stakeholder Reference Group
TEOMs	Tapered Element Oscillating Microbalances
TOR	Terms of Reference
TSP	Total Suspended Particulate
uPVC	Unplasticised Polyvinyl Chloride
URS	URS is a professional services company providing engineering and environmental expertise.
VOC	Volatile Organic Compound
WAPC	Western Australian Planning Commission
WASP	Wind Assessment Siting Program
WAWA	Water Authority of Western Australia

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