Government of Western Australia
Department of Water and Environmental Regulation

Decision Report

Application for Works Approval

Part V Division 3 of the *Environmental Protection Act 1986*

Works Approval Number	W6886/2024/1
Applicant	South32 Worsley Alumina Pty Ltd
ACN	008 905 155
File number	DER2024/000024
Premises	Worsley Alumina Refinery Gastaldo Road, ALLANSON WA 6225 Legal description - Lease No 3116/7574 being Wellington Locations 5314-5317 on Deposited Plan 220209 As defined by the premises maps attached to the issued works approval
Date of report	30/05/2024
Decision	Works approval granted

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1. Decision summary

This decision report documents the assessment of potential risks to the environment and public health from emissions and discharges during the construction and operation of embankment raise 6A of Bauxite Residue Disposal Area (BRDA) 5 and Stage 6 of BRDA 4X within the premises. As a result of this assessment, works approval W6886/2024/1 has been granted.

2. Scope of assessment

2.1 Regulatory framework

In completing the assessment documented in this decision report, the Department of Water and Environmental Regulation (the department; DWER) has considered and given due regard to its regulatory framework and relevant policy documents which are available at https://dwer.wa.gov.au/regulatory-documents.

2.2 Application summary and overview of premises

On 15 January 2024, the applicant submitted an application for a works approval to the department under section 54 of the *Environmental Protection Act 1986* (EP Act).

The application is to undertake construction works to raise the BRDA embankments for:

- BRDA 5 Cell 6 (Stage 6A) to be raised by 5m to a final height of RL 290.5 m AHD; and
- BRDA4X (Stage 6) to be raised by 5m to a final height of RL 309m AHD.

The premises relates to the Category 46: bauxite refining and has an assessed production capacity of 4.7 million tonnes per annum under Schedule 1 of the *Environmental Protection Regulations 1987* (EP Regulations) which is defined in Works Approval W4432/2008/1; Licence Amendment dated 24 August 2012 and EPA Ministerial Statement 719 (MS 719 amendment 30 Nov 2016). The infrastructure and equipment relating to this application and premises category have been considered by the department in line with *Guideline: Risk Assessments* (DWER 2020) are outlined in Licence L4504/1981/17.

Background

The Worsley Alumina Refinery is located approximately 15km north-west of the town of Collie and primary function is to processes bauxite mined from the nearby Boddington Bauxite Mine into calcined alumina via the Bayer process. The process generates approximately 2.44 tonnes of bauxite residue per tonne of alumina produced, and this is disposed into the onsite BRDA's each year. The residue is pumped to the BRDA's at an average 55% (by weight) solids at a rate of approximately 1,244 tonnes per hour (and with an average 1.5 tonnes/m^3 settled dry density)

The authorised maximum throughput of the premises is 4.7 million tonnes of bauxite per annum resulting in approximately 10.1 million tonnes of residue each year. In addition, approximately 105,000 tonnes of fly ash from coal combustion is also disposed of into the BRDA's each year. At this rate of production, the expected life of the refinery is 2078, when the refinery is likely to reach its capacity within the current footprint.

The premises has two main bauxite disposal areas within the premises boundary. To the north of the refinery, within the Northern Valley BRDA, lies: BRDA 1; BRDA 2, BRDA 4 (cells 1 & 2) and BRDA 4X (cells 1 & 2 have been merged) as shown in Figure 1 below.

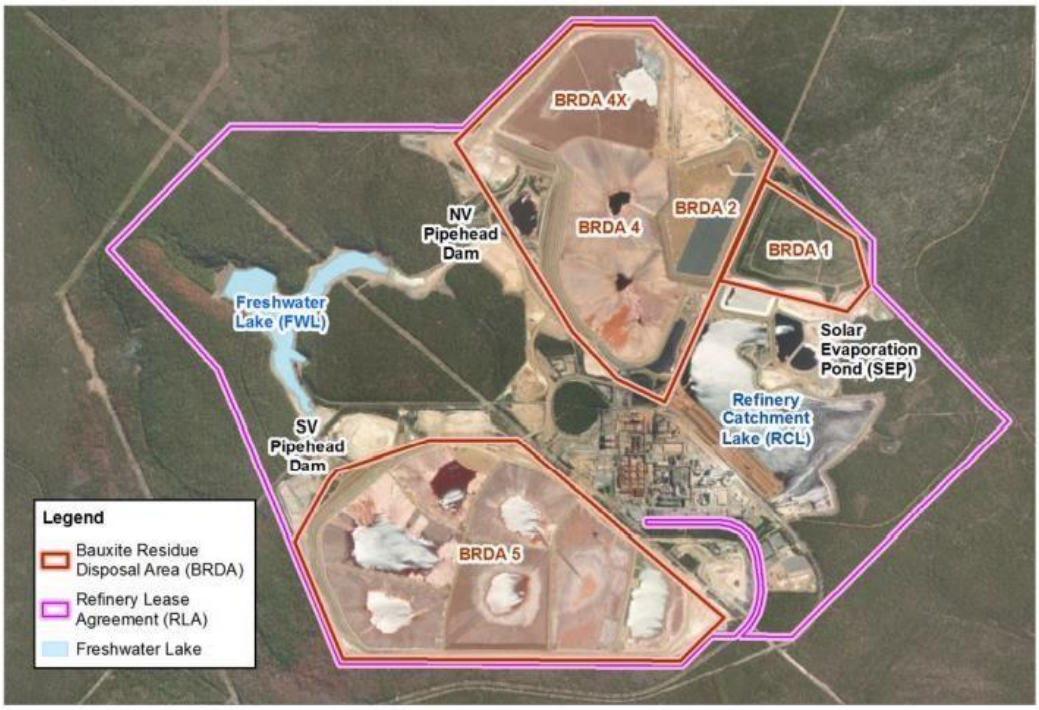

Figure 1: Bauxite Residue Disposal Area layout at the premises

Source Figure 3.1 of BRDA 4X (Stage 6) and BRDA 5 (Stage 6A) Embankment Raises – YR 25 South32 Limited Attachment 3B -Works Approval Supporting Document (South32, 2024).

To the south of the refinery lies the Southern Valley BRDA which consists of BRDA 5 (Cells 1 – 7) as shown in Figure 2 below.

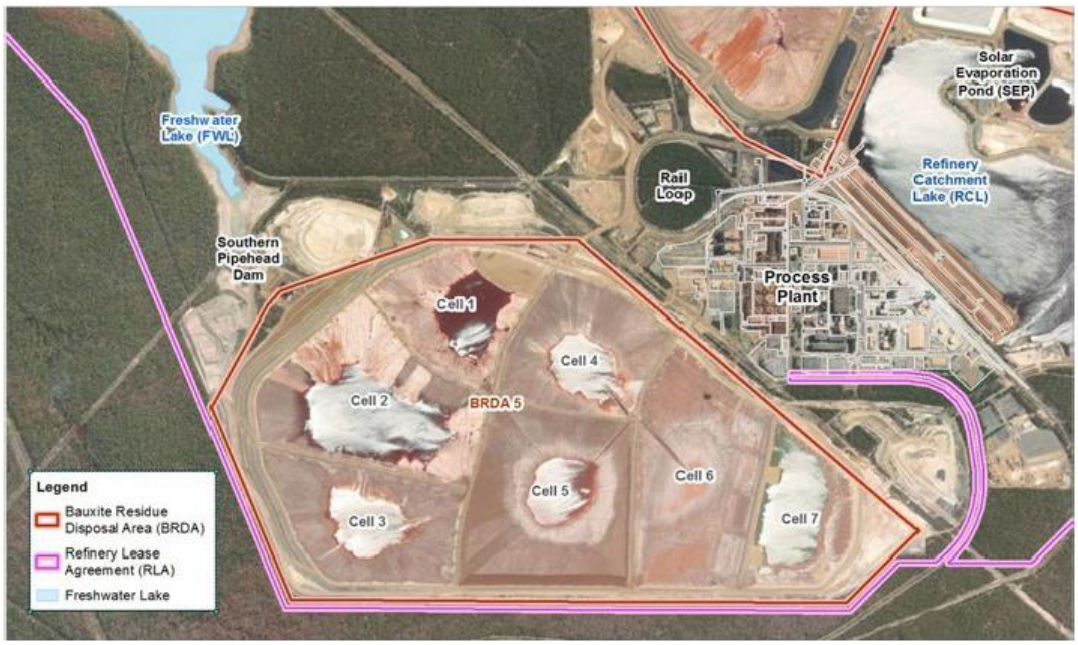

Figure 2: Bauxite Residue Area 5 showing cell layout

Source Figure 3.3 of BRDA 4X (Stage 6) and BRDA 5 (Stage 6A) Embankment Raises – YR 25 South32 Limited Attachment 3B -Works Approval Supporting Document (South32, 2024).

The fly ash and bauxite are conveyed to the BRDA's as a slurry and the removal of slurry water (liquor) through decant and drainage infrastructure to accelerate evaporation are critical to the operation of the premises. The BRDA 's are constructed of a low permeability clay liner with

two underdrainage systems, one beneath the compound to capture and divert rising groundwater away from the base of the BRDA; the second underdrainage system lies above the floor of the BRDA liner and collects contaminated seepage. Both underdrainage systems convey liquor and groundwater to the Southern Pipehead Dams (for BRDA 5) and to the Northern Pipehead Dam (for BRDA 1, 2 4 and 4X), where the liquor is then returned to the Refinery Catchment Lake (RCL) for processing. The two under drainage layers are separated by a clay drainage blanket, and the upstream toe drainage is connected to the leachate collection underdrainage system, and this is referred to as a Closed Liquor System.

The premises was originally granted approval under The *Alumina Refinery (Worsley) Agreement Act 1973*. As part of this agreement Act, it is required to maintain compliance with zero discharges to nearby sensitive water resources as the premises is located within the upper catchment of Augustus River and directly adjacent to a Public Drinking Water Source Protection.

Under the *Alumina Refinery (Worsley) Agreement Act 1973* the current maximum height of the BRDA's is RL 316 m AHD.

Mud farming practices

Testing has indicated that the optimal conveyance consistency of bauxite slurry is between 55%-58% by weight solids. At 54% solids content the beach angle formation, the decant pond size and the time taken to dewater the deposition mass is adversely affected. A slurry of 58% by weight solids and above, the pumping becomes restrictive. Water content is required to be maintained within the slurry prior to deposition, but once deposition has occurred, the objective changes to dewater and dry the material so that deposition rates can be maintained.

The Works Approval Holder introduced intensive 'mud farming' at the premises through the use of amphirolling from 2009 as one of the methods to accelerate dewatering the bauxite slurry and to assist with consolidate of the residue. Once the bauxite deposition surface reaches a depth layer of 1.1 m (average pours depth); the partially amphibious vehicles are used on the BRDA surface to roll and compact the deposition mass. The ploughing and ripping accelerates mud drying and compaction when compared with more traditional methods that rely on evaporative mud drying practices only. This measure has allowed to volume of bauxite processed at the refinery to increase from 3.5 Mtpa to 4.6 Mtpa over a similar deposition surface area and time period.

Extensive annual testing

Since 2011 the Occupier has undertaken carried out comprehensive annual surveys including a series of infield and laboratory testing of the deposition mass to understand the effects of mud farming on the geotechnical characteristics of the bauxite residue. This includes electric friction cone penetration testing with pore pressure measurements (EFCPTu) with vibrating wire piezometer network and survey monuments. The annual surveys initially commenced testing within relative shallow depths, and have managed to extend to the full depth of the DBRD's in some areas to a depth of 55m and has allowed for testing the floor of the underdrainage system (Closed Liquor System mentioned above) and the chemical cementing properties of the residue over time. Third party assessment of the information gathered through these tests indicates a higher than originally anticipated geotechnical shear strength, bulk density and factor of safety for the BRDAs under a range of operating scenarios such as post seismic loading, undrained deposition mass and saturated foundation materials.

Working to extending the BRDA structural zone

The Works Approval Holder has advised that in order to meet the requirements for dam wall stability during all phases of development: construction work, operations, closure and post closure, the occupier has imposed a goal of creating a structural zone within the BRDA's beyond what is required at the current embankment raise level and above what is required for a post closure structure of 316 m AHD. This has been undertaken to ensures that the embankments and deposition mass as it is designed and constructed now is capable of not only

accommodating current industry standards and requirements but to enables the occupier the option of applying to exceed the current 316 m AHD height and development limit of the storage facility, should this be applied for in the future (under the *Alumina Refinery (Worsley) Agreement Act 1973)*.

The structural zone is the outer extent of the BRDA dam' area that is capable of bearing the weight and form of the facility over its lifetime. The characteristics of the structural zone are used to calculate theoretical catastrophic 'slip surface' under worst case conditions based on conservative modelling estimations of dam failure. The current construction method allows for an additional 50m buffer (inside of the outer extent of the structural zone based on a hypothetical future deposition mass under conservative modelling estimations with a hypothetical height of 55m above the currently approved upstream embankment (see Figure 8). That is based one based on an assumed maximum BRDA height of RL 345.50 m AHD rather than 316m AHD.

The increased structural zone has reduced pore water content achieved through a range of water measures including:

- Quality assurance testing of structural zone materials in accordance with Earthworks Specifications FY2025-FY2027;
- amphirolling as described in the 'mud farming' subsection above;
- the use of an upstream internal toe drainage system at each raise (part of the Closed Liquor System);
- managing the rate of deposition to allow for evaporative drying and removal of water
- evenly spaced spigots to creates a sloped deposition beach on the upstream embankment;
- depth of pour;
- carefully controlling the location, size, extent of the decant pond;
- decant liquor recovery to the RCL;
- Use of piezometers to measure the phreatic surface within the embankments during operation;
- Use of predictive modelling, input of test field and lab data into the model and development of action criteria and use of Trigger Action Response Plan should criteria be reached;
- The use of internal and external finger drains to limit erosion and convey water away from the embankment walks;
- Drop drain use to convey water away from the BRDA; and
- Sloping embankments and crests that prevent pooling on embankments and crest surfaces.

The installation of the upstream toe drainage system (point 3 above) uses a series of slotted pipe polyvinyl chloride (PVC) pipes on the upstream (inside) embankment walls of approximately 50m length into the BRDA and the deposition mass. These are spaced at approximately 3 every 100m and reduce water pore pressure between the residue particles within deposition mass, without reducing the embankment stability (see Figure 4). The discharge of excess liquor within the residue will occur through the internal filter drain and closed pipe network to the floor drains where it can be conveyed to the Northern and Southern Pipe Head Dams for reuse.

These upstream drains will not be placed on all embankments through this works approval, only the western portion of BRDA 4X and the southern section of CRDA 5 Cell 6. Future works

approval applications may apply to constructs these upstream drains in other embankment walls (such as for the eastern embankment of BRDA 5 Cell 6 for Stage 8).

Proposed Works: BRDA 4X (Stage 6)

BRDA 4X commenced construction in 1999 within the northern valley that slopes from east to west/north west. Cell 4X was as an extension to Cell 4 constructed using the upstream method of construction. It originally consisted of 3 cells which were combined into one cell during Stage 5. The current height of BRDA 4X is 45m above ground level or RL 304m AHD and the proposed 5m raise will take the height to RL 309 m AHD. It is proposed that the final height of BRDA 4X will be reached by 2030. This works approval does not include an approval to extend the embankments beyond 309m. Table 1 provides a summary of works and Table 2 provides a summary of the capacity to BRDA 4X that are proposed to be undertaken during 2025 in accordance with this works approval.

Table 1: Proposed works to be undertaken to BRDA 4X Stage 6

Works to BRDA 4X

• Embankment raises by a maximum of 5m from RL 304m AHD to RL 309m AHD utilisng the following construction methods:
  ◦ upstream construction method for the northern and western perimeter;
  ◦ downstream embankment raise for eastern perimeter; and
  ◦ partial upstream construction for the southern splitter bund (embankment between BRDA Cell 4 and Cell 4X as shown in green in Figure 3).
• embankments constructed using residue and soil that meets Zone 2A Atterberg limits requirements only (rather than Zone 1A and Zone 2A);
• The three existing three decant towers will be extended (raised) by a maximum of 5m to a total of RL 309 m AHD;
• The decant causeway will be extended (raised) by 5m to a total of RL 309 m AHD;
• Amphiroller access ramps and operational maintenance and inspection points raised by up to 5m;
• Stormwater runoff features from perimeter embankments including sand fingers on the downstream batter (400mm thick by 4m wide at 8m) existing internal drainage collector pipes extended and proposed underdrain pipe installed beneath embankment (1 in 200 fall);
• Upstream internal drainage collector pipes extensions that extend 50m from the upstream toe of the embankment. Seepage to be conveyed through perforated pipe to HDPE collector pipes through the embankment into v-drains draining to the northern valley pipe head dam (as shown in Figure 4);
• Three vibrating wire piezometer arrays installed at three locations as shown in Figure 5;
• Drop structures spacing will be changed from 300m apart to 150m apart on the new embankments to improve water conveyance efficiency (and support a 1:250 minimum grade for the toe drains) and facilitate ease of maintenance of the structures;
• 2% crest fall towards the upstream edge of the embankment crest; and
• designed to contain rainfall of a greater than 1 in 5,000 year Annual Exceedence Probability 72 hour rainfall event added to a 0.2m (1:50) wave freeboard (freeboard of 700mm).

Table 2: Summary of Bauxite Residue Disposal Area 4X storage characteristics

Embankment 1)Stage 2)Cell 3)Configuration	Current crest height RL (m AHD)	rise (m)	New crest height RL (m)	Current Cell footprint area (ha)	New Cell foot print area (ha)	New Storage volume (Mm^3)	Cumulative Storage Volume (Mm^3)
1)Stage 6 2)Cell 4x 3)Downstream (eastern bund) Upstream (north and south western) Upstream and centreline (southern splitter bund with BRDA 4)	304	5	309	103	96.8	5	20

Figure 3 below shows the configuration of BRDA 4X .Figure 3 in schedule 1 of the Works Approval shows the upstream perforated underdrainage system that is proposed and the Vibrating Wire Pizometer array locations.

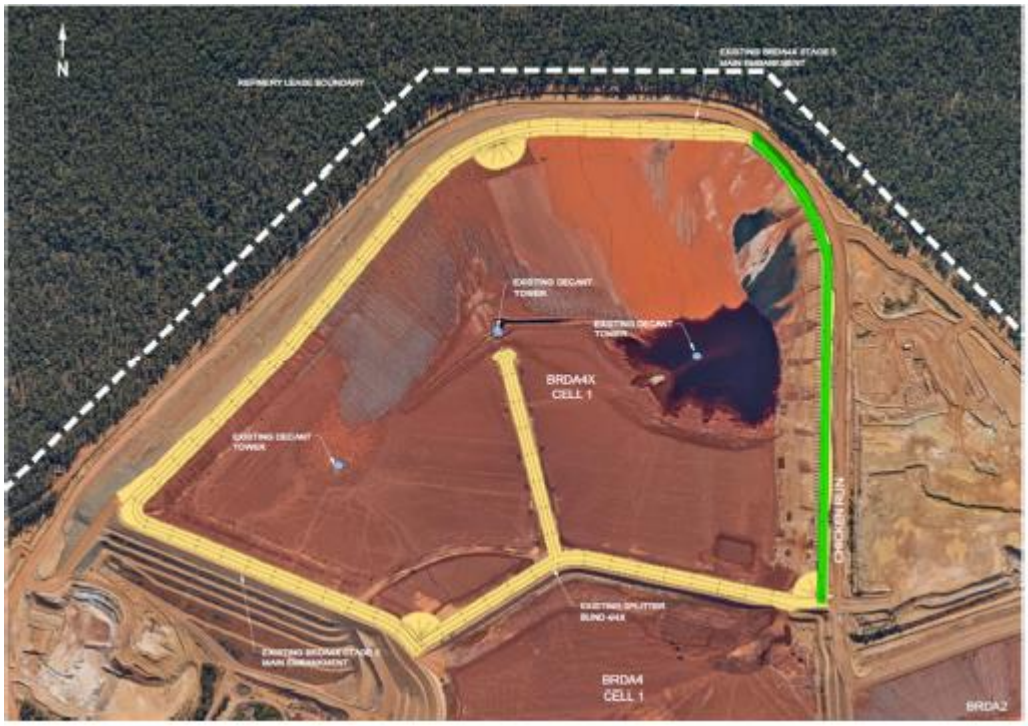

Figure 3 Bauxite Residue Disposal Area 4X proposed embankment raise works

Source Figure 4.1 of BRDA 4X (Stage 6) and BRDA 5 (Stage 6A) Embankment Raises – YR 25 South32 Limited Attachment 3B -Works Approval Supporting Document (South32, 2024).

Proposed Works: BRDA 5 Cell 6 (Stage 6A)

Since it was first constructed in 1994 with a 30m high starter embankment, the footprint of BRDA 5 has changed significantly as the paddock style compound expanded to complete the design footprint area within the southern valley. As the height of the perimeter embankments exceeded the localised topography, the construction method of the perimeter embankments has altered from downstream and centreline methods of construction to the upstream method of construction. The current embankment raise will be the last to utilise downstream and centreline construction methods along the external perimeter embankment, and future stages 7 to 10 will utilise the upstream method of construction only, with future embankment walls and future deposition mass being laid on top of the existing footprint area. This application is for Stage 6A and will cover the construction required for the 2025 year for Cells 6 only.

BRDA 5 was approved for construction on 12 March 1997 (Works Approval 01882) and has been subject to 6 stages of embankments raises and expansion works. The most recent works to BDRA 5 was an embankment raise to approximately 52m (RL 285.5 mAHD) above ground level (Stage 6B) and included works to the western half of the BRDA (cells 1, 2, 3, 4 and 5). These works are due to be completed in 2024 in accordance with Works Approval W6694/2022/1. The current application will raise BRDA 5 Cell 6 by 5m to 52m or RL 285.5 m AHD and part of Stage 6A work.

BRDA 5 is contained within a valley that slopes from east to west. The original embankment was 30m high and constructed in 1994 and construction methods have been downstream to the east at 5m increments that expand the footprint with each raise. Subsequent embankment raises occurred in 2001, 2005, 2009, 2014 and 2023 (Stage 6B). Following completion of stage 6A works (current stage) it is anticipated that all subsequent embankment raises will be upstream. The final height of the BDRA 5 is anticipated to be 315.5m AHD over 10 stages (stages 7 – 10 will be subject to future applications).

In accordance with Stage 6A (this works approval) and Stage 6B there are no alterations approved to Cell 7 of BRDA 5 with the exception of an upstream raise to the Cell 6 and Cell 7 dividing splitter bund as proposed under the current works Approval. The Works Approval Holder have advised that future works will investigate the suitability of Cell 7 to be reconfigured into a balance pond, for the storage of decant and particularly under possible extreme weather events, and to accommodate excess water generated from intensive mud farming.

Tables 3 provides a summary of these works and Table 4 provides a summary of the capacity to BRDA 5 Cell 6 that are proposed to be undertaken during 2025.

Table 3: Proposed works to be undertaken to BRDA 5 Stage 6A

Approved works Financial Year 2025

• Embankment raises by a maximum of 5m from RL 285.5m AHD to RL 290.5m AHD utilising the following construction methods:
  • Northern embankment will be constructed using the centreline method to the west; and the downstream method to the east as shown in Figure 6: construction method for the northern and western perimeter
  • Eastern embankment (which forms a splitter bund between Cell 6 and Cell 7) and the southern perimeter will be constructed using the upstream method;
• Stormwater runoff features from perimeter embankments including sand fingers on the downstream batter (400mm thick by 4m wide at 8m) existing internal drainage collector pipes extended and proposed underdrain pipe installed beneath embankment (1 in 200 fall)
• Upstream internal drainage collector pipes extensions that extend 50m from the upstream toe of the embankment. Seepage to be conveyed through perforated pipe to HDPE collector pipes through the embankment into v-drains draining to the southern valley pipe head dam (as shown in Figure 7).
• Of the three existing three decant towers, the centrally position tower will be extended (raised) by 5m and the remaining two will be capped (see Figure 8 and Figure 9)
• The decant causeway and decant pond will be reduced and repositioned to the west of the cell and extended (raised) by 5m AHD (as shown in Figure 9)
• Amphiroller access ramps and operational maintenance and inspection points raised by up to 5m
• Three vibrating wire piezometer arrays installed at three locations as shown in Figure 5;
• Drop structures spacing will be changed from 300m apart to 150m apart on the new embankments to improve water conveyance efficiency (and support a 1:250 minimum grade for the toe drains) and facilitate ease of maintenance of the structures.
• 2% crest fall towards the upstream edge of the embankment crest
• designed to contain rainfall of a greater than 1 in 5,000 year Annual Exceedance Probability 72 hour rainfall event added to a 0.2m (1:50) wave freeboard (freeboard of 700mm)
• Sandfingers spacing will be increased from 16m to 32 m on upstream raise

Table 4: Summary of Bauxite Residue Disposal Area 5 storage characteristics

Embankment **1)Stage** **2)Cell** **3)Configuration**	**Current crest height RL** **(m AHD)**	**rise** **(m)**	**New crest height RL (m)**	**Current Cell footprint area (ha)**	**New Cell foot** **print area (ha)**	**New Storage volume (Mm^3)**	**Cumulative Storage Volume** **(Mm^3)**
1)Stage 6A 2)Cell 6 3)Downstream, centerline northern wall Southern wall upstream Eastern splitter bund with Cell 7 upstream	285.5	5	290.5	67.8	67.6	3.4	13.1

Figure 4 below shows the configuration of BRDA 5 Cell 6 Stage 6A works including the point at which the northern embankment construction configuration changes from centerline to downstream. Figure 9 from Schedule 1 of the Works Approval shows the upstream perforated underdrainage system that is proposed to be constructed on the southern embankment only during stage 6A works.. Figure 5 shows the changes to the decant causeway and capping of two of the three decant towers, as well as the extended structural zone.

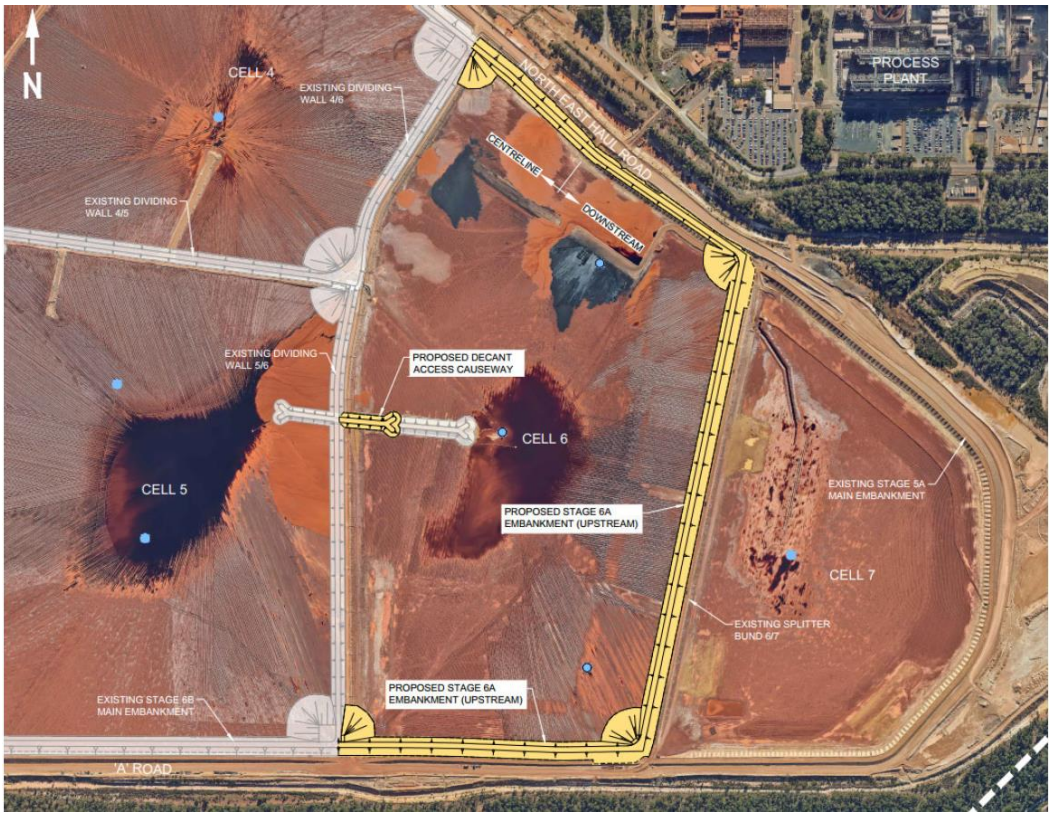

Figure 4: Bauxite Residue Disposal Area 5, Cell 6 Stage 6A works

Source Figure 6 of Design Report BRDA 5 Stage 6A (LOM Engineering, 2023) Attachment 8B -Works Approval Supporting Document (South32, 202

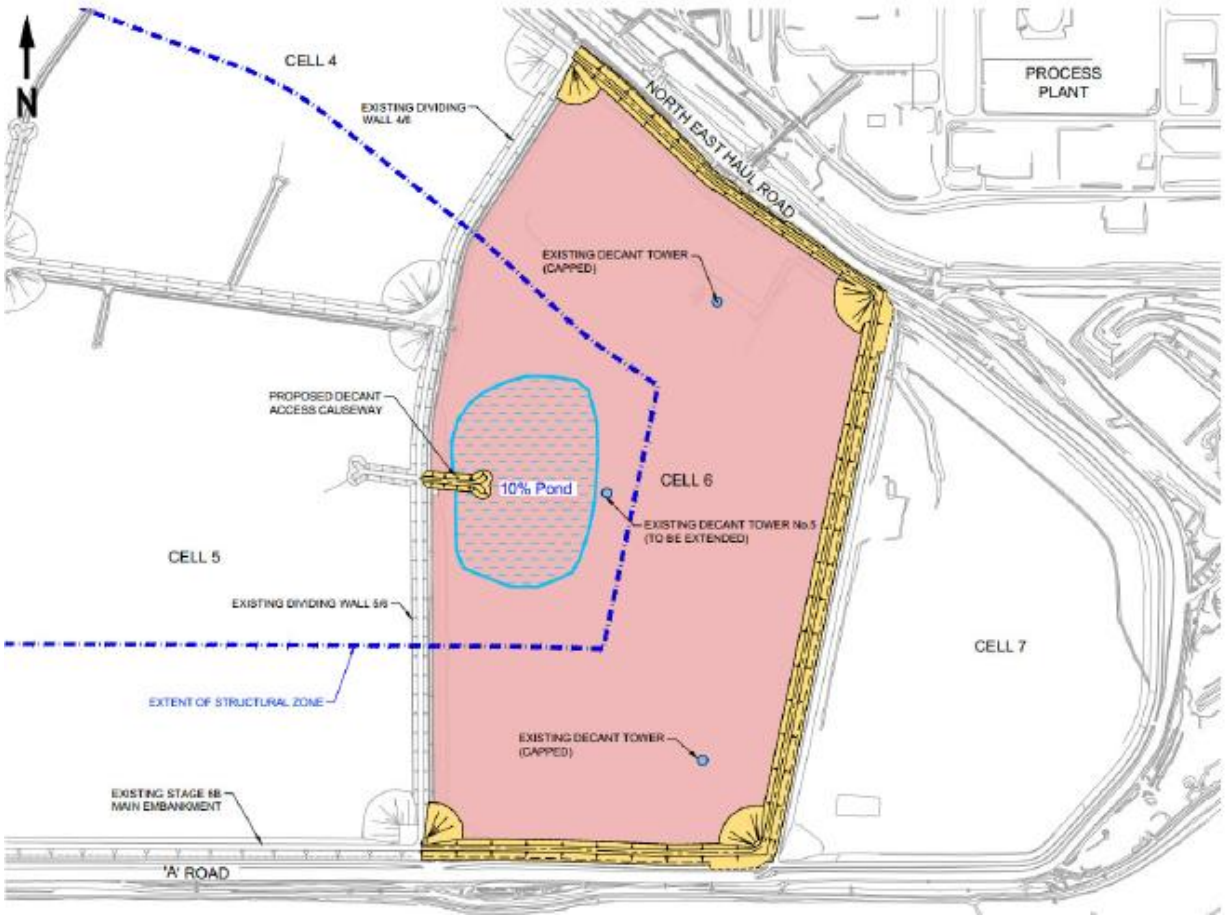

Figure 5: Bauxite Residue Disposal Area 5, Cell 6 Stage 6A reduced decant pond area and structural zone

Source Figure18 of Design Report BRDA 5 Stage 6A (LOM Engineering, 2023) Attachment 8B -Works Approval Supporting Document (South32, 2024).

2.3 Department of Energy, Mines, Industry Regulation and Safety (DEMIRS)- geotechnical review summary

The application was referred to DEMIRS to advise on the geotechnical aspects of the proposed embankment raised to BRDA 4X and BRDA 5 Cell 6. DEMIRS noted that Worsley Alumina Refinery is not subject to the provisions of the Mining Act 1978 and a Geotechnical Inspector at DEMIRS conducted a geotechnical review of the proposal based on

- 'BRDA 4X (Stage 6) and BRDA 5 (Stage 6A) embankment raises - YR 25

  Attachment 3B – Works approval supporting document' (January 2024, South 32).
- 'Design report BRDA 4X stage 6' prepared by LOM Engineering (November 2023)
- 'Design report BRDA 5 - stage 6A' prepared by LOM Engineering (October 2023)
- 'South32 Worsley Alumina water management plan' (2021, South 32)

Based on this review, the following comments have been made :

- *A number of geotechnical studies have been completed including liquefaction and dam break assessments. The design information presented appears to meet the DEMIRS, ANCOLD and GISTM code of practice and guideline requirements if South 32 follow the*

requirements outlined in the design reports.

- *DWER should receive the geotechnical study reports for stability assessments and confirm stability is adequate before the deposition commences.*
- *The design, construction, operation and closure of all tailings storage facilities must comply with the WHS Act and Mines Regulations, outdated legislation (MSIA) is referenced in the works approval document.*

2.4 Part IV of the EP Act

Ministerial Statement (MS) 719 applies to the Worsley Alumina Refinery and the associated Boddington Bauxite Mine. In relation to the current application, Worsley Alumina is required to implement the Water Resource Management Plan for the protection and management of nearby proclaimed water resources and to give effect to a zero discharge to these natural resources, and thereby not diminish their environmental value or use. The site undertakes a monthly water balance assessment which includes measurement of daily rainfall, pan evaporation and predictive rainfall events such that stormwater capture. BRDA 5 decant systems will be designed to accommodate the requirement to maintain a normal operating pond at approximately 10% of the cell area and provide pumping capacity to remove the ANCOLD design storm within 30 days. This capture and diversion allows for zero discharge following the incidence of a 1:1000 year annual exceedance rainfall event. In emergency situations the site undertakes water transfer between all onsite containment systems (as required).

All surface and groundwater monitoring is undertaken under the MS with the purpose of noting changing rainfall patterns, and to addresses strategic water source planning and to protection of water quality in the Augustus River, which is located downstream of the refinery. It provides for the maintenance of environmental water use, surface and groundwater quality monitoring and management and clean-up of spills, as well as on site contamination.

In relation to fugitive dust emissions from the BDRA's, MS 719 also applies to the management of fugitive dust emissions, incidents and complaints management as well as annual reporting on ambient particulate air quality. The main source of dust at the refinery is from the BRDA's and this is influenced by the moisture of the dry BRDA's, trafficable area dust lift off, construction activities, prevailing weather and wind conditions and ongoing dust mitigation and management measures.

3. Risk assessment

The department assesses the risks of emissions from prescribed premises and identifies the potential source, pathway and impact to receptors in accordance with the *Guideline: Risk Assessments* (DWER 2020).

To establish a risk event there must be an emission, a receptor which may be exposed to that emission through an identified actual or likely pathway, and a potential adverse effect to the receptor from exposure to that emission.

3.1 Source-pathways and receptors

3.1.1 Emissions and controls

The key emissions and associated actual or likely pathway during premises construction which have been considered in this decision report are detailed in Table 5 below. Table 5 also details the control measures the applicant has proposed to assist in controlling these emissions, where necessary.

Table 5: Proposed applicant controls

Emission	Sources	Potential pathways	Proposed controls
Construction			
Dust	Transport, mixing, compaction of materials for the construction of embankments, internal causeways, splinter bunds, construction ramps, vehicle movements, lift-off from stockpiles and/or stored product, earthworks etc.	Air / windborne pathway	Water carts Surface binding agents Adherence to construction material moisture requirements Cessation of a particular operation or an amendment to operational procedure when dust cannot be controlled Air Quality Management Plan
Noise		Air / windborne pathway	All onsite machinery compliant with vehicle noise emission requirements. Site will conduct works in accordance with Section 4 of AS 2436-2010 Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites (standards Australia 2010) Separation distances are such that any noise and vibration from construction works is sufficient that will not occur.
Sediment	Mobilised by stormwater run off	Overland flow	Surface water flow from BRDA 5 Cell 6 and BRDA 4X is captured by gravel lined spoon drains, diversion culverts to the Freshwater Lake via silt traps. The diversion channels have been designed with a 6- hour probably maximum precipitation event. These channels lead to rock lined drop structures. The spacing will now be limited to 150m in length to improve the conveyance of water. Construction of a bund on the downstream side of the construction areas so that loose materials subject to mobilization to stormwater runoff will be undertaken such that the drainage of rainfall falls to the upstream side of embankments where possible. Water quality monitored within the Freshwater Lake include parameters for turbidity. If exceedance of a trigger level is exceeded, as defined in the sites Trigger Action Response Plan an investigation into the source of the exceedances and well as implementation of corrective action will occur to address the cause of the incident.
Operation			

Emission	Sources	Potential pathways	Proposed controls
Bauxite residue Slurry water: containing Al2O3, Na2, CO3, and SO4	Embankment failure (Dam Break)	Direct discharge and overland flow to nearby land and water	<u>Construction</u> The construction methods determine the capacity of the embankments to remain stable under a range of conditions during operations. Construction will occur in accordance with the South 32 Worsley Alumina Pty Ltd Bauxite Residue Disposal Area (BRDAs) 070 -Earthworks specifications FY2025-2027 and the premises Construction Quality Assurance Plan. The Works Approval Holder provides these reports that demonstrates the embankment raise is compliant with the • Code of Practice for Tailings Storage Facilities (DMIRS) • Australian National Committee on Large Dams (ANCOLD) • Guidelines on Tailings Dam Planning Design, Australian National Committee on Large Dams (ANCOLD) • Guidelines on Dam Safety Management (ANCOLD); and Design Report BRDA 4X – Stage 6 (2023) and Design Report BRDA 5 – Stage 6A (2023) contain an assessment of the stability of the dam under seismic loading, drained and undrained conditions. The reports claims the BRDA 5- Stage 6 (Cell 6) and BDRA 4X when constructed to the above specifications, will meet the minimum factors of safety. These claims are yet to be independently assessed, and deposition will not be authorized under this Works Approval until DWER has obtained third party independent geotechnical assessment of the Design Report and until any critical issues identified through the third-party review, are satisfactorily addressed. <u>Operation</u> Management of water within the raise prior to deposition mass being consolidated is through careful management of tailings deposition and supernatant in accordance with the BRDA Operating Maintenance and Surveillance Manual (South32 2022), • Daily inspections of BRDA’s • Delivery mudline fitted with dropper pipe spigots that minimize velocity of deposition

Emission	Sources	Potential pathways	Proposed controls
			• Spigots paced an average of 72m apart and managed 4 -hourly short pours around perimeter embankments to maintain pond around the decant tower; • Beach length of approximately 500m with tailings deposition of 55% solids and a 0.6% degree beach slope; • Wet pours of a maximum of 1.1m at a time; • Use of amphirollers on wet pours within 72hours of pour until an undrained shear strength of 28kPa is achieved for each layer to achieve 72% final solids content; • Shear strength of each rise to be a minimum of 100kPa to a depth of 1m prior to further embankment raises • Insitu vane shear strength testing is undertaken to verify assumptions prior to embankments; • Use of vibrating wire piezometers arrays in embankment walls at various depths location to monitor operational water within the deposition mass • Management of centralized decant pond within each cell to an approximate maximum 10% of overall surface area • To maintain ~10% decant pond area, excess water is stored in water management ponds on site (Southern and Northern Valley Pipe Head Dam, Water Body 1, SEP1, 3, 2A, 4; Refinery Catchment Lake, Freshwater; • Comprehensive and daily monitoring of BRDA's including mudlines delivering bauxite to the BRDA's, decant recovery pipelines and valves, scheduled maintenance, incident recording and reporting • The site is operated as a closed

Emission	Sources	Potential pathways	Proposed controls
			system, contaminated water and leachate from spills is contained within the premises • Groundwater and surface monitoring is undertaken to validate effectiveness of controls (under Ministerial Statement 719)Lake) • Maintenance of operational freeboard; • Daily recording of rainfall and evaporation, monthly reconciliation of water balance • Upstream toe drains and sand fingers installed on upstream face of embankment • Trigger Response Action Plan to identify and respond to issues as they arise
Bauxite residue, and decant water Slurry water: containing Al2O3, Na2, CO3, and SO4	Leaks and spills from pipelines, mudlines, pumps and associated infrastructure	Direct discharge and overland flow to nearby land and water	• Comprehensive and daily monitoring of BRDA's including mudlines delivering bauxite to the BRDA's, decant recovery pipelines and valves, scheduled maintenance, incident recording and reporting • Trigger Response Action Plan to identify, respond to issues as they arise (site specific spill management and recovery procedure) • The site is operated as a closed system, contaminated water and leachate from spills is contained within the premises • Groundwater and surface monitoring is undertaken to validate effectiveness of controls (under Ministerial Statement 719)
Bauxite residue, and decant water Slurry water: containing Al2O3, Na2, CO3, and SO4	Overtopping of BRDA due to excess loading or heavy rainfall events or both.	Overland flow, direct discharge to soil, infiltration to groundwater	• Maintenance of operational freeboard of 0.5 between the tailings at the top of the beach and the embankment crest (inclusive of wave action) • The beach angle over 100m of beach is 0.6m • Only 2 or 3 cells are actively used at any one time, may be used in the event of an extreme storm event to temporarily store storm water

Emission	Sources	Potential pathways	Proposed controls
			• Maximum operating levels are calculated to only be exceeded in a 1:1,000 year annual recurrence interval storm event ; • Ability to move contaminated storm water following high rainfall events to other containment infrastructure on site such that a water from an extreme 1: 1000- year annual rainfall incidence 72 hour duration event event is completely contained within the premises infrastructure, enabling compliance with the sites “zero discharge” requirements under the Worsley State Agreement Act 1973. This includes Cell 7 of BRDA, Southern and Northern Valley Pipe Head Dams, Water Body 1, SEP1, SEP2, SEP3 and SEP4, Refinery catchment Lake and Freshwater Lake as a last resort. Trigger Response Action Plan to identify and respond to issues as they arise
Leachate Slurry water: containing Al2O3, Na2, CO3, and SO4	Seepage of contaminants through the base of the BRDA liner causing groundwater contamination and mounding	Direct discharge to soil, infiltration to groundwater	• Inspection of underdrain at Southern and Norther pipe head dam inflow • Report any changes • Vacuum pumping to unblock pipes if required • Trigger Response Action Plan to identify and respond to issues as they arise • The site is operated as a closed system, contaminated water and leachate is contained within the premises; • Extensive groundwater and surface monitoring is undertaken to validate effectiveness of controls (under Ministerial Statement 719)
Contaminated stormwater run off		Overland flow, direct discharge to soil, infiltration to groundwater	• Design such that stormwater that falls on the downstream side of perimeter embankments is diverted to of gravel lined spoon drains at the toe of embankment leading to rock drops

Emission	Sources	Potential pathways	Proposed controls
			• The rock drops report to southern diversion dam through southern valley silt trap to the southern arm of the freshwater lake • Periodic testing of Freshwater Lake is undertaken.in accordance with Ministerial Statement 719
Dust lift off	Dry deposition surface	Air / windborne pathway	• Dust from the the BRDA's is managed in accordance with the sites Air Quality and Dust Management Plan – RLA Business Blueprint and includes: • Daily visual monitoring of BRDA surface • Dust monitoring stations upstream and downstream to monitor dust lift off • Addition of dust suppression and surface binding agents hydro mulch and Gluon500 to control dust over residue deposition areas • Use of water carts and sweeping in dry weather • Mechanical ploughing and ripping of BRDA surfaces • Trigger levels and corrective action response and reporting

3.1.2 Receptors

In accordance with the *Guideline: Risk Assessment* (DWER 2020), the Delegated Officer has excluded the applicant's employees, visitors, and contractors from its assessment. Protection of these parties often involves different exposure risks and prevention strategies, and is provided for under other state legislation.

Table 6 below provides a summary of potential human and environmental receptors that may be impacted as a result of activities upon or emission and discharges from the prescribed premises *(Guideline: Environmental Siting*, DWER 2020).

Table 6: Sensitive human and environmental receptors and distance from prescribed activity

Human receptors	**Distance from prescribed activity**
Single Rural dwellings	No rural dwellings within 5km of the premises. Single residential dwelling approximately 6 km due south and north of the proposed works
Town of Allanson	Approximately 11km south of the premises boundary
Environmental receptors	**Distance from prescribed activity**
Priority 1 Public Drinking Water Source Area (PDWSA)	The Priority 1 Harris River Catchment Dam Area
Major watercourses/waterbodies	The refinery Freshwater Lake feeds into the Augustus River
Groundwater	Groundwater beneath BRDA is collected via a specifically designed groundwater underdrainage system that reports to the freshwater lake. The groundwater beneath BRDA 6 Cell 6 is not available with the nearest bore approximately 480m east of the embankment. However an assessment from 2012 indicates the water to be between 270m AHD and 280 m AHD. Groundwater beneath BRDA 4X from an assessment undertaken in 2019 is inferred to be between 275m and 255m AHD
Rights in Water and Irrigation Act 1914 (RiWI Act)	Premises lie across the boundary of the following surface water areas: Collie River Irrigation District Brunswick River and tributaries
Waterways Conservation Areas	Leschenault Inlet Management Area adjoins western point of the premises boundary
Threatened/Priority Flora	A number of priority flora species within proximity of the premises boundary, the closest to the being 580m, 660m south and 1.5 and 1.7km Southwest respectively of the BRDA 5.

3.2 Risk ratings

Risk ratings have been assessed in accordance with the *Guideline: Risk Assessments* (DWER 2020) for each identified emission source and takes into account potential source-pathway and receptor linkages as identified in Section 3.1. Where linkages are in-complete they have not been considered further in the risk assessment.

Where the applicant has proposed mitigation measures/controls (as detailed in Section 3.1.1), these have been considered when determining the final risk rating. Where the delegated officer considers the applicant's proposed controls to be critical to maintaining an acceptable level of risk, these will be incorporated into the works approval as regulatory controls.

Additional regulatory controls may be imposed where the applicant's controls are not deemed sufficient. Where this is the case the need for additional controls will be documented and justified in Table 7.

Works approval W6886/2024/1 that accompanies this decision report authorises construction only. The conditions in the issued works approval, as outlined in Table 7 have been determined in accordance with *Guidance Statement: Setting Conditions* (DER 2015).

Table 7: Risk assessment of potential emissions and discharges from the premises during construction

Risk events					Risk rating [1] C = consequence L = likelihood	Applicant controls sufficient?	Conditions of works approval	Justification for additional regulatory controls
Sources / activities	**Potential emission**	**Potential pathways and impact**	**Receptors**	**Applicant controls**				
Construction								
Civil construction works from BRDA 5 embankment raise Stage 6B	Dust from civil and construction activities	Air and wind	Single rural dwelling approximately 6km due south and north of premises	Refer to Section 3.1	C = Slight L = Rare **Low Risk**	*Y*	Conditions 1, 2, 10 and 11	Standard works approval construction, compliance and reporting conditions will apply Condition 10 and 11 require the Works Approval Holder to record and report any complaints or incidents
	Noise from civil and construction activities	No Pathway			C = Slight L = Rare **Low Risk**	*Y*	Conditions 1, 2, 10 and 11	Standard works approval construction, compliance and reporting conditions will apply Condition 10 and 11 require the Works Approval Holder to record and report any complaints or incidents

Risk events					Risk rating [1] C = consequence L = likelihood	Applicant controls sufficient?	Conditions of works approval	Justification for additional regulatory controls
Sources / activities	**Potential emission**	**Potential pathways and impact**	**Receptors**	**Applicant controls**				
	Sediments mobilized by stormwater	Overland flow No pathway as stormwater surrounding the BRDA reports to the Freshwater Lake	Augustus River approximately 2km north west of the BRDA		C = Slight L = Rare **Low Risk**	*Y*	Conditions 1, 2, 10 and 11	Standard works approval construction, compliance and reporting conditions will apply Condition 10 and 11 require the Works Approval Holder to record and report any complaints or incidents
Operation								
Embankment Failure	Bauxite residue and slurry water containing Al2O3, Na2, CO3, and SO4	*Overland flow* causing inundation of adjacent ecosystems, the freshwater Lake leading to the Augustus River	Nearby vegetation in state forest, Augustus River and catchment area, approximately 2km north west of the BRDA	Refer to Section 3.1	Unable to determine at the present time	To be determined	Conditions 1, 2, 5, 6 ,7, 8 and 9	See detailed risk assessment below
Leaks and spills from pipelines, mudlines, pumps and associated infrastructure	Bauxite residue, and decant water Slurry water: containing Al2O3, Na2, CO3, and SO4	Surface runoff directed towards the Freshwater Lake, where water is diluted and diverted to the refinery for operational use, or where it may be	Augustus River approximately 2km north west of the BRDA	Refer to Section 3.1	C = Slight L = Rare **Low Risk**	Y	Condition 1, 3 and 4	Standard works approval construction, compliance and reporting conditions will apply Water Balance is managed under

Risk events					Risk rating [1] C = consequence L = likelihood	Applicant controls sufficient?	Conditions of works approval	Justification for additional regulatory controls
Sources / activities	**Potential emission**	**Potential pathways and impact**	**Receptors**	**Applicant controls**				
Overtopping of BRDA	Slurry water: containing Al2O3, Na2, CO3, and SO4	discharged to the Augustus River potentially causing ecosystem disturbance or impacting surface water quality		Refer to Section 3.1	C = Slight L = Rare **Low Risk**	Y	Condition 1, 3 and 4	the Part IV Ministerial Statement 719
Contaminated stormwater run off	Stormwater contaminated with dilute Al2O3, Na2, CO3, and SO4			Refer to Section 3.1	C = Slight L = Rare **Low Risk**	Y	Condition 1, 3 and 4	
Contamination of groundwater via leachate/seepage	Slurry water: containing Al2O3, Na2, CO3, and SO4	Infiltration through clay liner to soil and groundwater No pathway as BRDA has an underdrainage system above the clay liner for collection and diversion of contaminated seepage towards the Refinery Catchment Lake and another underdrainage system below the clay liner to divert groundwater away from BRDAs towards the Freshwater Lake	Shallow aquifer discharging to Freshwater Lake and Augustus River	Refer to Section 3.1	C = Slight L = Rare **Low Risk**	Y	NA	This is managed under the Part IV Ministerial Statement 719

Risk events					Risk rating [1] C = consequence L = likelihood	Applicant controls sufficient?	Conditions of works approval	Justification for additional regulatory controls
Sources / activities	**Potential emission**	**Potential pathways and impact**	**Receptors**	**Applicant controls**				
		Overland flow causing inundation of adjacent ecosystems, including forests, the freshwater Lake leading to the Augustus River	Nearby vegetation, nearby Augustus River approximately 2km northwest of the BRDA	Refer to Section 3.1	C = Slight L = Possible **Medium Risk**	Y	NA	This is managed under the Part IV Ministerial Statement 719

Note 1: Consequence ratings, likelihood ratings and risk descriptions are detailed in the *Guideline: Risk Assessments* (DWER 2020).

3.3 Embankment Failure

The primary control mechanism to prevent, control and mitigate impacts to the environment from embankment raises is the structural integrity of the residue and the BRDA. The design and construction characteristics of the embankment raises will determine if the BRDA has the ability to contain bauxite residue under variable conditions. This will be validated by a third party.

This application does not support the deposition of bauxite residue into the BRDA. This is to enable the applicant sufficient time for the applicant to submit information relating to the audit of the BRDA once constructed, and to allow DWER to review the assessment of geotechnical stability information submitted of the embankment raises, without affecting the ability to process bauxite, through the delay of these time critical construction activities. On this basis an assessment of embankment stability will be undertaken post construction. Reporting may be undertaken in a staged approach as construction is completed, which will support a staged commencement of deposition within the cells included in this works approval application.

Embankment construction details

The Works Approval Holder has advised the use of variable construction materials for the proposed embankment materials. This includes on site borrow materials as well as stockpiled materials that meet the material specifications and construction quality assurance practices and auditing requirements as detailed in 070 -Earthworks Specifications FY 2025-2027 (received at part of the current Application, Worsley 2024).

The materials used are required to meet predetermined design criteria and will be blended and tested during construction to ensure they possess suitable engineering properties for use in embankments.

The accepted industry design criteria to be used in this instance is derived from the ANCOLD Guidelines and the Code of Practice for Tailings Storage Facilities in Western Australia (DMP, 2013). Considerations include compaction density, particle size, shear strength, Atterberg limits, consolidation, erosion resistance, dispersion characteristics, elasticity (shrinkage), slake durability, hydraulic conductivity and resistance to liquefactions (DMP 2013).

Construction Quality Control

The Works Approval Holder has a Construction Quality Assurance Plan to oversee the construction works and ensure that site preparation, embankment construction meets the designs specifications contained within the Works Approval Application.

This includes overview of the design and aims to incorporate any items excluded from the prescribed quality assurance works and construction activities (methods and Materials) such as modifications to proposed construction, compliance testing, health safety and environment. It is an independent certification and reporting of the construction process.

The accepted industry design criteria to be used in this instance are derived from ANCOLD Guidelines and the Code of Practice for Tailings Storage Facilities in Western Australia (DMP, 2013).

Following completion of works the Works Approval Holder is required to submit a construction compliance report as well as an audit report on the BRDA, to confirm that the construction materials and methods have been undertaken in accordance with the design report as part of this application, and that the foundations of the BRDA are suitable to support the current raise.

4. Decision

The Delegated Officer has concluded that the proposed embankment raise is capable of being constructed to the required standards with relevant controls to mitigate the environmental risk.

However, in construction and operation there is the potential for a number of characteristics to

vary from the design specifications; therefore, the overall performance could vary depending on the scale and nature of the variations, and these may be impacted by variable foundation materials and construction methods. Consequently, requirements have been added to the Works Approval for the audit of the BRDA to ensure that the controls remain adequate.

As such, in accordance with Works Approval conditions 7, 8 and 9, the Works Approval Holder is required to audit the works in accordance with the accepted industry standards for Tailings storage Facility, and to demonstrate that BRDA 5 is capable of remaining stable over the range of operating scenarios, over the long term.

The Works Approval Holder is required to complete a geotechnical study to inform the stability and thereby suitability of the embankments for the long-term storage of bauxite residue, following completion of the construction works approved by this Works Approval. The Works Approval Holder will submit construction compliance documentation for the works including critical containment infrastructure and these also need to be assessed and verified as compliant by the CEO prior to the occupier being able to commence deposition into the newly raised embankments. The deposition, if approved, is to occur under the operating Licence for the premises: L4504/1981/17.

5. Consultation

The Department received comments from two stakeholders other than DEMIRS (this is summarised in Section 2.3 of this report). Comments were received from a concerned community member on 8 April 2024 and from the Williams Environment Group Inc on 29 March 2024 Table 5 provides a summary of the consultation undertaken by the department.

Table 5: Consultation

Consultation method	Comments received	Department response
Application advertised on the department's website on 25 March 2024	1. Comments received regarding applicant history-failure to mention breaches; 2. Failure of DWER to advertise all documents; 3. Concern regarding dust from onsite combustion engines 4. Concern regarding impacts to biodiversity and surface water impacts; Question regarding Hotham River as a sensitive resource/receptor; 5. How dust and noise managed by proponent from the mine.	1. Although the application failed to mention breaches of other occupier at other premises, the occupier is considered suitable to hold a works approval for this facility due to the historical compliance with the regulatory controls applied to this site. 2. Initially all documents were not advertised on the DWER website. When this was identified the missing documents were uploaded and the advertised period extended by another 21 day period (total of 42 days). 3. Dust from combustion engines was not considered within scope for this application as it is not within scope for this application. 4. Biodiversity and surface water impacts (including Hotham River) are

		managed under the Part IV Ministerial Statement for the premises and considered out of scope for this application. Furthermore, the BRDA's contain a dual underdrainage layer which is considered sufficient to manage seepage under the current Works Approval. 5. Dust and Noise impacts at the mine site are out of scope of this application which is for an embankment raise at the refinery only.
Department of Mines, Industry Regulation and Safety (DMIRS) advised of proposal 6 February 2024	See section 2.3 of this decision report.	Comments incorporated within the assessment
Applicant was provided with draft documents on 9 May 2024	On 29 May 2024 a comment was received requesting the period between the audit report required to be submitted by condition 7(b) and the commencement of deposition be reduced from 60 to 30 days to allow for reduced and/or changes to construction timeframes.	Change accepted.

6. Conclusion

Based on the assessment in this decision report, the delegated officer has determined that a works approval will be granted, subject to conditions commensurate with the determined controls and necessary for administration and reporting requirements.

References

1. Department of Environment Regulation (DER) 2015, *Guidance Statement: Setting Conditions*, Perth, Western Australia.
2. Department of Water and Environmental Regulation (DWER) 2020, *Guideline: Environmental Siting*, Perth, Western Australia.
3. DWER 2020, *Guideline: Risk Assessments*, Perth, Western Australia.
4. Environmental Protection Authority (EPA) 2018, Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual, Environmental Protection Authority, Perth, WA.
5. LOM Engineering (2023) *Design report BRDA 4X stage 6*
6. LOM Engineering (2023) *Design report BRDA 5 - stage 6A*
7. South32 Worsley Alumina Refinery (2024) *BRDA 4X (Stage 6) and BRDA 5 (Stage 6A) embankment raises - YR 25 Attachment 3B – Works approval supporting document*.

8. South32 Worsley Alumina (2022) BRDA Operation Maintenance and Surveillance Manual: Operating Manual;

9. South32 Worsley Alumina (2021) *South32 Worsley Alumina Water Management Plan*