

4. Object and Principles of the EP Act

In addition to considering how the Proposal has responded to the objectives and principles of the EP Act, this chapter:

- summarises the EPA's key environmental factors of relevance to this Proposal
- sets out the strategic approach the assessment has taken to address the avoidance aspect of the mitigation hierarchy
- provides a description of the outcomes of the work undertaken in response to the ESD items relating to Biodiversity Indicators.

4.1 Environmental Principles

Section 4A of the EP Act states that the object of the Act is to protect the environment of the State, having regard to the following principles:

- the precautionary principle
- the principle of intergenerational equity
- principles relating to improved valuation, pricing, and incentive mechanisms
- the principle of the conservation of biological diversity and ecological integrity; and
- the principle of waste minimisation.

Table 4.1 lists how the object and principles have been considered in relation to the Proposal.

4.2 Key Environmental Factors

Environmental factors are those parts of the environment that may be impacted by an aspect of a proposal. The EPA has thirteen environmental factors, organised into five themes: Sea, Land, Water, Air and People. The EPA assesses the significance of a proposal's environmental impacts against the objective of each environmental factor, as well as making a holistic assessment of the acceptability of the proposal against the EP Act principles (Table 4.1) (EPA 2021c).

The approved ESD (Alcoa 2021a) identified seven key environmental factors and one other environmental factor, as presented in Table 4.2. Table 4.2 presents the impacts assessed against each factor and the relevant MNES, as identified in the approved ESD.

Key environmental factors are those where the Proposal may potentially cause a significant impact to the environment. Other environmental factors are those where the Proposal will not cause a significant impact but has potential to interact with the environment.

Consistent with the EPA's Instructions on how to prepare an Environmental Review Document (EPA 2024), this document presents a detailed assessment of the key environmental factors and a summary assessment of the other environmental factors.

Table 4.1 Principles of the Western Australian Environmental Protection Act 1986

Principle	Consideration of Principle in the Proposal
<p>1. The precautionary principle</p> <p><i>Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.</i></p> <p><i>In the application of the precautionary principle, decisions should be guided by:</i></p> <p><i>(a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and</i></p> <p><i>(b) an assessment of the risk-weighted consequences of various options.</i></p>	<ul style="list-style-type: none"> • The Proposal has been subject to environmental studies and impact assessment for the identified key environmental factors, conservation significant species and relevant MNES. • The mitigation hierarchy of avoidance, minimisation and rehabilitation has been applied to reduce residual impacts to as low as practicable. • All native vegetation cleared for mining will be rehabilitated to a biodiverse Jarrah forest ecosystem, using Alcoa’s rehabilitation methods developed over five decades of research and practice. • Where there are potential significant residual impacts from Alcoa’s clearing, these are counterbalanced by an ecological offset proposal. • Extensive ecological surveys have been conducted to identify and protect important populations and habitats for conservation significant flora, fauna and ecological communities. • Mining will adopt preventative risk management incorporating multiple barriers to protect drinking water quality, including: <ul style="list-style-type: none"> ○ no mining in Serpentine Pipehead Dam catchment ○ no mining within the Serpentine Dam or South Dandalup Dam Reservoir Protection Zones ○ open area limited to less than 30 per cent of the area of any subcatchment ○ no mining in areas of average slope greater than 16 per cent and maintaining at least two metres separation with groundwater ○ workforce education, health monitoring, incident reporting/response (including waste bagging), signage and access restrictions for the field workforce ○ mine facilities including all hazardous material storage, sewage treatment, vehicle washdowns and maintenance workshops located outside of Reservoir Protection Zones ○ avoidance zones incorporate a 100 m buffer to streams ○ drainage and sediment controls provided for all disturbed areas including mine pits and haul roads ○ use firefighting foams free of per and polyfluoroalkyl substances (PFAS) ○ refuelling of haul trucks at fuel bays in mine facilities ○ secondary containment for all fuel, oil and hazardous material storage ○ off-site disposal of all wastes (except for on-site sewage treatment at mine facilities). • Numerical modelling adopting conservative assumptions indicates that catastrophic fuel or sewage releases from mining are unlikely to impact human health. Reservoir monitoring data over 20 years does not demonstrate an impact from mining on water quality at reservoir offtakes.

Principle	Consideration of Principle in the Proposal
	<ul style="list-style-type: none"> • Alcoa coordinates with and provides funding to DBCA to implement prescribed burning within mine regions to reduce the likelihood and severity of wildfires, protecting associated drinking water catchments. • Predictions of refinery air quality impacts are based on an updated emissions inventory incorporating empirical emissions monitoring and testing data. The Health Risk Assessment adopts conservative assumptions and has concluded that the refinery poses a low risk to human health. • Predictions of mine air quality impacts are based on conservative assumptions of worst-case mining operations and exclude natural dust suppression from rainfall. • The Scope 1 Greenhouse Gas emissions from the refinery will be regulated by the Australian Government’s Safeguard Mechanism to achieve net zero Scope 1 emissions by 2050. • Disturbance to Aboriginal heritage will be avoided as far as practicable or otherwise be minimised and occur in accordance with the recommendations of the Gnaala Karla Booja Aboriginal Corporation. • No disturbance will occur to State Heritage Register or Local Heritage Survey sites. • Public access to POW Camp 20 to be maintained during the operation of Myara North. • The Proposal was amended to reduce the southern portion of the Holyoake mine and avoid crossing the Bibbulmun Track and Pinjarra-Williams Road, thereby minimising impacts to recreational and residential receptors. • The Proposal was amended to reduce the north western extent of the Myara North DE, so providing a larger separation distance between it and the Jarrahdale townsite, and will not cross Kingsbury Drive or Jarrahdale Road, thereby minimising impacts to recreational and residential receptors. • The Munda Bididi Trail section within the Myara North mine DE has been realigned to outside the mine DE, to maintain public access to the trail. • Mining operations within noise sensitivity zones will be restricted to avoid noise impacts to sensitive receptors. • The works to increase the refinery’s production will result in no net increase in noise levels at receptors. • Visual buffers will be maintained to minimise foreground and mid ground visual impacts to receptors within the Jarrah forest. • Alcoa considers that the Proposal has been developed in accordance with the precautionary principle and does not pose a risk of serious or irreversible damage; the now closed and fully rehabilitated Jarrahdale bauxite mine demonstrates this.
<p>2. The principle of intergenerational equity</p>	<ul style="list-style-type: none"> • All native vegetation cleared for mining will be rehabilitated to a biodiverse Jarrah forest ecosystem, using Alcoa’s rehabilitation methods developed over five decades of research and practice.

Principle	Consideration of Principle in the Proposal
<p><i>The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.</i></p>	<ul style="list-style-type: none"> • Long term research and monitoring demonstrates that Alcoa’s rehabilitation maintains biodiversity and ecological integrity and is resilient to climate change such as drought and heat waves. • Long term research, water quality monitoring and numerical modelling indicates that mining and rehabilitation is unlikely to substantially increase salinity or turbidity nor substantially reduce inflows into drinking water reservoirs. • Conservative estimates of erosion, assuming no mitigation measures, indicate that mining is unlikely to cause significant siltation of reservoirs over the long term. • The Scope 1 Greenhouse Gas emissions from the refinery will be regulated by the Australian Government’s Safeguard Mechanism to achieve net zero Scope 1 emissions by 2050. • Alcoa will maintain access to recreational trails and facilities within the mine DE or else reinstate access to recreational trails and facilities upon mine closure and handover, as far as practicable and as agreed with DBCA. • Mine rehabilitation is expected to limit high to moderate visual impacts to elevated viewpoints in the Monadnocks Conservation Park to approximately 16-17 years, peaking midway at about 8 years. • Mining is not anticipated to be visible to other viewpoints, including at Jarrahdale and Dwellingup townsites, rural properties, Serpentine National Park, Lane Poole Reserve, and public roads. • Alcoa considers that the Proposal will not significantly impact the health, diversity and productivity of the environment over the long term and is consistent with this principle.
<p>3. Principles relating to improved valuation, pricing and incentive mechanisms</p> <p><i>(1) Environmental factors should be included in the valuation of assets and services.</i></p> <p><i>(2) The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.</i></p> <p><i>(3) The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.</i></p>	<p>Design, construction and operational mitigation measures have been fully costed into the Proposal. These include:</p> <ul style="list-style-type: none"> • rehabilitation of all mined areas to a biodiverse Jarrah forest ecosystem • ecological offsets for potential significant residual impacts • water and energy efficiency measures • drainage, sediment and hazardous materials containment measures • off-site disposal of all wastes (except for on-site sewage treatment at the Mine sites) • mine facilities decommissioning and, if required, remediation at mine closure • acid sulfate soil investigation and, if required, management • dust suppression and monitoring • additional noise controls at the Refinery to prevent increased noise levels at receptors • the Munda Biddi Trail realignment to be outside of the Myara North mine DE

Principle	Consideration of Principle in the Proposal
<p><i>(4) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.</i></p>	
<p>4. The principle of the conservation of biological diversity and ecological integrity <i>Conservation of biological diversity and ecological integrity should be a fundamental consideration.</i></p>	<ul style="list-style-type: none"> • Mining will not occur in granite outcrops, biodiverse vegetation fringing granite outcrops or in swamps or riparian vegetation. These vegetation types represent important habitats for conservation significant flora and fauna and potential priority ecological communities. • Mine infrastructure alignments will be subject to targeted surveys and designed to avoid populations of threatened flora, Black Cockatoo known and suitable nesting trees and populations of Carters Freshwater Mussel. • All native vegetation cleared for mining will be rehabilitated to a native Jarrah forest ecosystem, using Alcoa’s rehabilitation methods developed over five decades of research and practice. • Groundwater investigations and design will be undertaken to prevent waterlogging or salinity impacts to potential groundwater dependent ecosystems within individual subcatchments. Mining is expected to provide a temporary offset to the decline in groundwater levels and streamflows since the 1990s resulting from declining rainfall over the Jarrah forest. • Where there are potential significant residual impacts from the Proposal, these are counterbalanced by an offset proposal. • Alcoa considers that the Proposal will not significantly impact biological diversity or ecological integrity and is consistent with this principle.
<p>5. The principle of waste minimisation <i>All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment</i></p>	<ul style="list-style-type: none"> • Mine overburden and topsoil will be locally reused for mine rehabilitation. • Mining will maximise utilisation of existing mine facilities and infrastructure to minimise waste generation from construction of new facilities and infrastructure. • The increase in production at the Refinery will incorporate water efficiency measures and use alternative water sources to limit consumption of potable water.
<p>Description of how the object of the EP Act has been considered</p>	
<p>Alcoa has planned the Proposal to incorporate measures to protect the environment of Western Australia, including consideration of the EP Act principles as presented above. The Proposal includes impact avoidance and minimisation measures, rehabilitation, and an offset strategy to counterbalance significant residual impacts.</p>	

Table 4.2 Environmental Factors Relevant to the Proposal

Environmental factor	Factor objective	Impacts assessed	Relevant MNES	Section of this ERD
Key environmental key factors				
Flora and Vegetation	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.	<ul style="list-style-type: none"> • Direct impacts to flora and vegetation as a result of clearing • Indirect impacts to flora and vegetation as a result of: <ul style="list-style-type: none"> ○ Introduction and/or spread of weeds ○ Introduction and/or spread of dieback ○ Spills and/or leaks from storage and handling of hazardous materials and waste ○ Dust emissions ○ Altered hydrology/groundwater regimes, including waterlogging. 	Listed threatened species and communities	Section 5
Terrestrial Fauna	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.	<ul style="list-style-type: none"> • Direct impacts to terrestrial fauna as a result of injury/mortality from fauna entrapment or vehicle/equipment collisions • Indirect impacts to fauna as a result of: <ul style="list-style-type: none"> ○ Introduction and/or spread of weeds ○ Introduction and/or spread of dieback ○ Attraction of feral animals ○ Light emissions from infrastructure ○ Noise emissions from construction and operational equipment ○ Spills and/or leaks from storage and handling of hazardous materials and waste 	Listed threatened species Listed migratory species	Section 6
Terrestrial Environmental Quality	To maintain the quality of land and soils so that environmental values are protected.	<ul style="list-style-type: none"> • Soil salinisation as a result of mining-induced saline groundwater rise • Disturbance of potential acid sulfate soils • Erosion of post-mining landforms • Contamination from spills and/or leaks from storage and handling of hazardous materials and waste. 	n/a	Section 7
Inland Waters	To maintain the hydrological regimes and quality of groundwater and surface water so that	<ul style="list-style-type: none"> • Increases in stream salinity as a result of mining-induced saline groundwater discharge • Increased water supply for alumina refining 	Ramsar wetlands	Section 8

Environmental factor	Factor objective	Impacts assessed	Relevant MNES	Section of this ERD
	environmental values are protected.	<ul style="list-style-type: none"> • Increased sediment from erosion of post-mining landforms • Contamination from spills and/or leaks from storage and handling of hazardous materials and waste • Potential impacts to public health • Potential for service interruption of the public drinking water supply • Water quality deterioration in streams and reservoirs (for example, turbidity, salinity, pathogens, hydrocarbons, PFAS, nutrients, pesticides), including cumulative impacts from existing mining operations • Potential disturbance to the Peel-Yalgorup System Ramsar site through potential changes to water quality and changes to the hydrological regime of the region 		
Air Quality	To maintain air quality and minimise emissions so that environmental values are protected.	<ul style="list-style-type: none"> • Dust generation from construction and mining activities • Gaseous and particulate emissions from power generation, alumina refining and residue storage 	n/a	Section 9
Greenhouse Gas Emissions	To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change	<ul style="list-style-type: none"> • Increased net greenhouse gas emissions from mining and refining activities. 	n/a	Section 10
Social Surroundings	To protect social surroundings from significant harm.	<ul style="list-style-type: none"> • Disturbance to Aboriginal heritage sites • Disturbance to historical heritage sites • Impacts to amenity through construction and operational noise • Impact to visual amenity from mining operations and infrastructure • Impact on recreational use of areas. 	n/a	Section 11 (Heritage) Section 12 (Amenity)
Other environmental factors				

Environmental factor	Factor objective	Impacts assessed	Relevant MNES	Section of this ERD
Subterranean Fauna	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.	<ul style="list-style-type: none"> <li data-bbox="792 322 1599 379">• Potential for significant habitats or populations of subterranean fauna. 	n/a	Section 13

4.3 Impact Assessment Approach

4.3.1 Overview

Alcoa has undertaken a comprehensive environmental impact assessment against each of the key environmental factors outlined above, in accordance with the approved ESD and the EPA instructions for preparing an ERD (Environmental Protection Authority (EPA) 2024). The environmental impact assessment has drawn on a broad range of datasets, detailed studies of environmental baseline and historic environmental conditions, and numerical modelling to assess the potential for impacts to sensitive receptors.

The impact assessment has been undertaken using the best information available based on preliminary mine planning and consideration of environmental constraints. As discussed in Section 1.9.2.1, Alcoa has developed an Avoidance Zone, Low Disturbance Area and Mine Development Zone over the Mine DE. This has enabled an estimate of distribution of direct and indirect impacts within the Mine DE. The confidence in the estimated direct impacts has been improved through empirical validation with historic disturbance patterns in the Huntly Mine, and for indirect impacts through adopting conservative assumptions in numerical modelling. The Avoidance Zone is discussed in Section 4.3.3.2 and the apportionment of disturbance is discussed in Section 4.3.4.

As described in Section 1.10 and Section 2.1.1.1, the Proposal is a significant amendment of the Pinjarra Refinery Efficiency Upgrade (PREU) project approved under MS 646 in 2004, and accordingly this ERD assesses the potential impacts of the Proposal in the context of the PREU. This includes the combined effects on the four environmental factors previously assessed by the EPA for the PREU, namely:

- Air quality
- GHG emissions
- Noise (social surroundings)
- Water supply (inland waters)

The context and combined effects (i.e. cumulative impacts) of the Proposal and the PREU are assessed in this ERD, as presented in Table 4.3. The assessment of residual impact for each of the four environmental factors is made with respect to the cumulative impact of the Proposal and the PREU as the approved proposal.

Table 4.3 Assessment of the Proposal as a significant amendment to the PREU

Key environmental factor	Context described in ERD section	Combined effects described in ERD section
Inland waters (water supply)	Section 8.4.7.2	Section 8.4.7.2
Air quality	Section 9.3.3.4, Section 9.3.3.5	Section 9.4.4
GHG emissions	Section 10	Section 10
Social surrounds (noise)	Section 12.3.3.3	Section 12.4.2.2

As discussed in Section 2.1.1.3, in parallel with this Proposal the EPA is assessing the impact of Alcoa's 2022-2026 and 2023-2027 MMPs (Assessments 2384 and 2385), which are also significant amendments to the PREU. Independent from this Proposal, Assessments 2384 and 2385 will also undertake an assessment of their cumulative impact with the PREU as the approved proposal. The cumulative impacts of all three Proposals (Assessments 2253, 2384 and 2385) and the PREU will be considered in Section 17 of this ERD.

The environmental impact assessment has incorporated the mitigation hierarchy consistent with Western Australian guidance, which is in order of priority:

- Impact avoidance
- Impact minimisation
- Rehabilitation.

Alcoa's framework for impact avoidance includes a commitment to protecting key environmental values and areas identified by environmental studies and stakeholder consultation, as detailed in Section 4.3.5.

Alcoa has a mature environmental management system for its WA Operations, which is compliant with international standards and is detailed in Section 2.3.

Alcoa is an acknowledged world leader in mine site rehabilitation and has evolved its rehabilitation program over more than five decades of research and development. Alcoa's rehabilitation program is detailed in Section 2.4.

Alcoa implements preventative risk management to protect drinking water quality in accordance with the Australian Drinking Water Guidelines, as discussed in Section 8 of this ERD.

Where, after applying the mitigation hierarchy a significant residual impact is identified, Alcoa has proposed an offset strategy to counterbalance the impact, in accordance with the Western Australian and Commonwealth Environmental Offsets Framework. Alcoa's offset strategy is detailed in Section 14 of this ERD.

4.3.2 Limitations

Alcoa accepts that the ecological survey data gathered for the Proposal does not meet the exact requirements of the EPA's survey guidelines for flora and vegetation, terrestrial fauna and short range endemic invertebrate fauna. Undertaking detailed and targeted surveys to EPA guidelines over tens of thousands of hectares of contiguous forest is logistically challenging and highly inefficient of survey resources considering that about 70 per cent of the Mine DE will not be disturbed.

The survey methodologies used are described in Section 5.3 and 6.3 and reflect Alcoa's longstanding survey practices which have provided data over many years to support MMP approvals. Alcoa considers that the data gathered is sufficient to meet the ESD requirements, while acknowledging that further ecological and inland waters data will be gathered, in accordance with the relevant EPA guidelines, during pre-clearance studies undertaken over confirmed disturbance footprints and subcatchments (see Sections 5.5.1, 6.5.1 and 8.5.1).

EPA noted similar shortcomings in the survey data gathered for the Worsley Mine Expansion – Revised Proposal (Report 1768, 2024) but determined it could proceed with its assessment despite the survey limitations.

4.3.3 Impact avoidance framework

Alcoa have developed an integrated impact avoidance framework for the Mine component of the Proposal, which avoids impacts across multiple key environmental factors. The impact avoidance framework is outlined in the figure below and commenced during planning of the Proposal Mine DE. Alcoa will continue to implement impact avoidance during the design, construction and operation phases of the mine component of the Proposal.



Figure 4 Impact avoidance framework

The impact avoidance framework has been developed with consideration of relevant policy and guidance, including threatened species conservation guidance and recovery plans (see Sections 5.5.1 and 6.5.1), the Australian Drinking Water Guidelines, and Water Corporation Catchment Risk Assessment (see Section 8.5.1).

4.3.3.1 Selection of Development Envelope

Alcoa selected the boundaries of the Mine DE during early planning, prior to detailed exploration and the development of preliminary mine plans and infrastructure alignments in the mine regions. In selecting the Mine DE, Alcoa considered environmental values and areas at the regional scale while balancing strategic mine planning, as had been its standard practice for past mine region transitions approved via the State Agreement's MMP process.

The Myara North mine DE boundaries were originally selected to avoid Class A reserves comprising the Serpentine National Park and Monadnocks Conservation Park and the Jarrahdale townsite urban area (Figure 4-1).

The Holyoake mine DE boundaries were initially selected to avoid the Class A Lane Poole Reserve to the south (Figure 4-2).

Post referral alterations

Following the referral of the Proposal, Alcoa removed a 7,300 ha area of the Myara North DE. This was in response to ongoing stakeholder consultation, and increased the distance of mining from the Jarrahdale townsite and rural properties in the Balmoral area east of Jarrahdale, avoiding the Serpentine Pipehead Dam catchment, as well as avoiding potential impacts to the majority of mature age forest in the Myara North DE (Figure 4-1).

In response to matters raised in stakeholder consultation, the Holyoake Mine DE boundary was modified to remove a 1,012 ha southern portion primarily to protect the following key values and areas relating to social surroundings (Figure 4-2):

- Rural properties in the Inglehope and Etmilyn areas
- Bibbulmun Track
- Pinjarra-Williams Road.

Response to regulator and consultee comments

After the consideration of regulator comments on a draft of this ERD, and community concerns, mining of bauxite within Reservoir Protection Zones (RPZ) was removed from the Proposal. The mine DEs for Myara North and Holyoake were amended to remove the RPZs and the Infrastructure Corridor DEs altered to encompass all critical infrastructure within the RPZs. Alcoa's commitment to excluding mining activities in the RPZs from the Proposal will allow the new water management and drainage control practices which Alcoa has put in place in accordance with the 2023-27 MMP approval and Section 6 Exemption Order conditions to be monitored over a longer period. This will enable Alcoa to confirm and demonstrate the effectiveness of the new water management and drainage control practices before any future mine plans within these RPZ areas are contemplated. The removal of mining activities within the RPZs avoids impacts to the biodiversity values within them.

In addition, amendments were made to the mine DEs to avoid impacts to recreational tracks and trails surrounding the DEs and exclude two scientific sites identified in consultation with the DBCA. Increased certainty in design options for critical infrastructure components, e.g. the access to Myara North from the existing Myara crusher, and the future conveyor spur to the Holyoake mine DE, enabled the reduction of the Infrastructure Corridor DEs.

As a result of comprehensive consultation with Gnaala Karla Booja (GKB) Traditional Owners regarding the need to avoid or minimise impacts to cultural heritage values within the Pinjarra Refinery DE, Alcoa is deferring any additional disturbance within the Pinjarra Refinery DE, so avoiding any biodiversity or social surroundings impacts.

Table 4.4 provides a summary of the DE changes made post receipt of comments. As presented, the changes to the Myara North and Holyoake are such that a decrease in the total Mine DE and disturbance area is achieved even with the addition of the O'Neil DE.

When determining the O'Neil DE, Alcoa was able to utilise knowledge obtained from its previous mining operations in the O'Neil region and more advanced mine planning and environmental studies as discussed in the 25-29 MMP. Alcoa considers the O'Neil DE maximises the ability to avoid impacts to key values through excluding them from the DE.

Table 4.4 Comparison of areas between pre and post regulator and consultee comments Development Envelopes and disturbance footprints of the Proposal

Component	Pre-comment (ha)	Post-comment (ha)	Net change in area (ha)*
Myara North DE			
Mine DE	13,748	9,997	3,751 reduction
IC DE	1,655	708	947 reduction
Total	15,403	10,705	4,698 reduction
Holyoake DE			
Mine DE	9,158	6,421	2,736 reduction
IC DE	9,542	1,203	8,340 reduction
Total	18,700	7,624	11,076 reduction
O'Neil DE			
Mine DE	Not included	5,571	5,571 addition
Mine DE total			
Combined DE	34,103	23,900	10,203 reduction
Combined Disturbance Footprint	8,323	7,500	823 reduction
Pinjarra Refinery DE			
Refinery Disturbance Footprint	1,695	1,396	299 reduction

* Areas are to +/- 1 ha due to rounding to whole numbers

In addition to choosing and then refining the Mine DEs to avoid key values and areas, the Mine DEs were also selected to adjoin existing or historic mine regions, to maximise the utilisation of existing infrastructure and so minimise clearing of native vegetation in State Forest. Although State Forest is relatively widespread and subject to multiple uses including timber harvesting (until end 2023), minimising clearing in State Forest contributes to maintaining the ecological integrity of the NJF as a whole.

4.3.3.2 Avoidance Zones

Within the three mine DEs Alcoa has adopted a series of environmental, social and heritage constraints to define zones within which it will not develop mine pits to avoid the direct impacts arising from the extraction of bauxite ore.

The following are considered of high environmental, social and heritage value and are the constraints that guide the identification and development of the Avoidance Zone (AZ):

Flora and Vegetation

- Currently mapped Old Growth Forest as identified by DBCA
- Mature Forest (age since last harvested >70 yrs) where not underlain by an economically viable bauxite ore deposit.
- Vegetation types associated with potential occurrences of the 'Granite Communities of the northern Jarrah Forest' Priority 3 PEC.
- Potential groundwater dependent ecosystems, including riparian and swamp vegetation (100 m buffer) and upland vegetation on seasonally moist soils

- Granite outcrops identified from aerial imagery (50 m buffer)
- Areas of previous rehabilitation

Terrestrial Fauna

- Confirmed Black Cockatoo known and suitable nest trees (30 m buffer)
- Vegetation Types that make up the following fauna habitats, which are of restricted distribution in the jarrah forest:
 - Blackbutt Forest
 - Bullich forest
 - Flooded Gum woodland
 - Granite outcrop
 - Lowland Jarrah-Marri Forest
 - Melaleuca dampland
 - Wandoo woodland

Inland Waters

- Mapped riparian and swamp vegetation (100 m buffer)
- Kennedy's Pool (50 m buffer)

Social Surroundings

- Registered Aboriginal heritage sites (10 m buffer)
- Aboriginal heritage sites identified during surveys (10 m buffer)
- Aboriginal Ethnographic sites (100 m buffer)
- DBCA identified scientific sites for forest thinning trials (300 m)
- DBCA Forestcheck sites (100 m buffer)
- Existing roads (100 m buffer)
- European heritage sites (10 m buffer)
- Areas of CAR Informal reserve (includes a 200 m buffer to the Bibbulmun Track)

The Avoidance Zones are mapped in Figure 4-1 (Myara North DE), Figure 4-2 (Holyoake DE) and Figure 4-3 (O'Neil DE) against a selection of key constraints avoided, and the Avoidance Zone areas are tabulated in Table 4.5 and Table 4.6. As presented, the Avoidance Zones comprise a total of 7,929 ha or 33.2 per cent of the Proposal DE.

Areas within the Mine DE outside of the Avoidance Zones where mine pit development and ore extraction will take place are termed the Mine Development Zone (MDZ). The Mine Development Zones are mapped in in Figure 4-1 (Myara North DE), Figure 4-2 (Holyoake DE) and Figure 4-3 (O'Neil DE) and are tabulated in Table 4.5 and Table 4.6. As presented, the Mine Development Zones comprise a total of 12,599 ha or 52.7 per cent of the Proposal DE.

Low Disturbance Areas

To develop a mine DE, it is necessary to construct infrastructure and haul roads, which are considered to be low disturbance activities relative to pit development and ore extraction. These low disturbance activities will be constrained to the MDZ where possible, but it will be necessary to undertake them within the Avoidance Zones for various design reasons e.g., to connect the pits and provide a route to the crushers, connect facility areas to the public highway, construct a conveyor spur to the proposed Holyoake crusher. Areas within the Avoidance Zones where these activities must be undertaken have been reclassified as Low Disturbance Areas (LDA).

The LDAs associated with haul roads providing connections between pits comprise an indicative haul road alignment and a buffer. The buffer is to allow for the potential realignment of the haul road to avoid any constraints identified by future pre-clearance surveys. Therefore, it is not

anticipated that it will be necessary to clear the entirety of an LDA. Where an LDA encompasses a haul road stream crossing, a fauna crossing beneath the haul road will be provided if necessary to maintain Avoidance Zones connectivity.

The Proposal includes Infrastructure Corridor DEs (ICDEs) for Myara North and Holyoake. The Proposal does not include pit development and ore extraction within the ICDEs. Therefore, no areas of the ICDEs are classified as MDZ. Within the Myara North ICDE 243 ha has already been cleared as part of Alcoa's existing Huntly Mine operations at Kisler, that are not a part of this Proposal.

While the precise locations of the LDAs could alter with future iterations of the mine plan or in response to as yet unidentified constraints, the locations of certain LDAs will be fixed. The LDA fixed are typically associated with crossings of watercourses that are registered Aboriginal heritage sites. A Section 18 consent will be sought for these crossings that will define a heritage disturbance area, the LDA fixed cannot extend outside of this area.

The Low Disturbance Areas are mapped in Figure 4-1 (Myara North DE), Figure 4-2 (Holyoake DE) and Figure 4-3 (O'Neil DE) and are tabulated in Table 4.5 and Table 4.6. As presented, the Low Disturbance Areas comprise a total of 3,371 ha or 14.1 per cent of the Proposal DE.

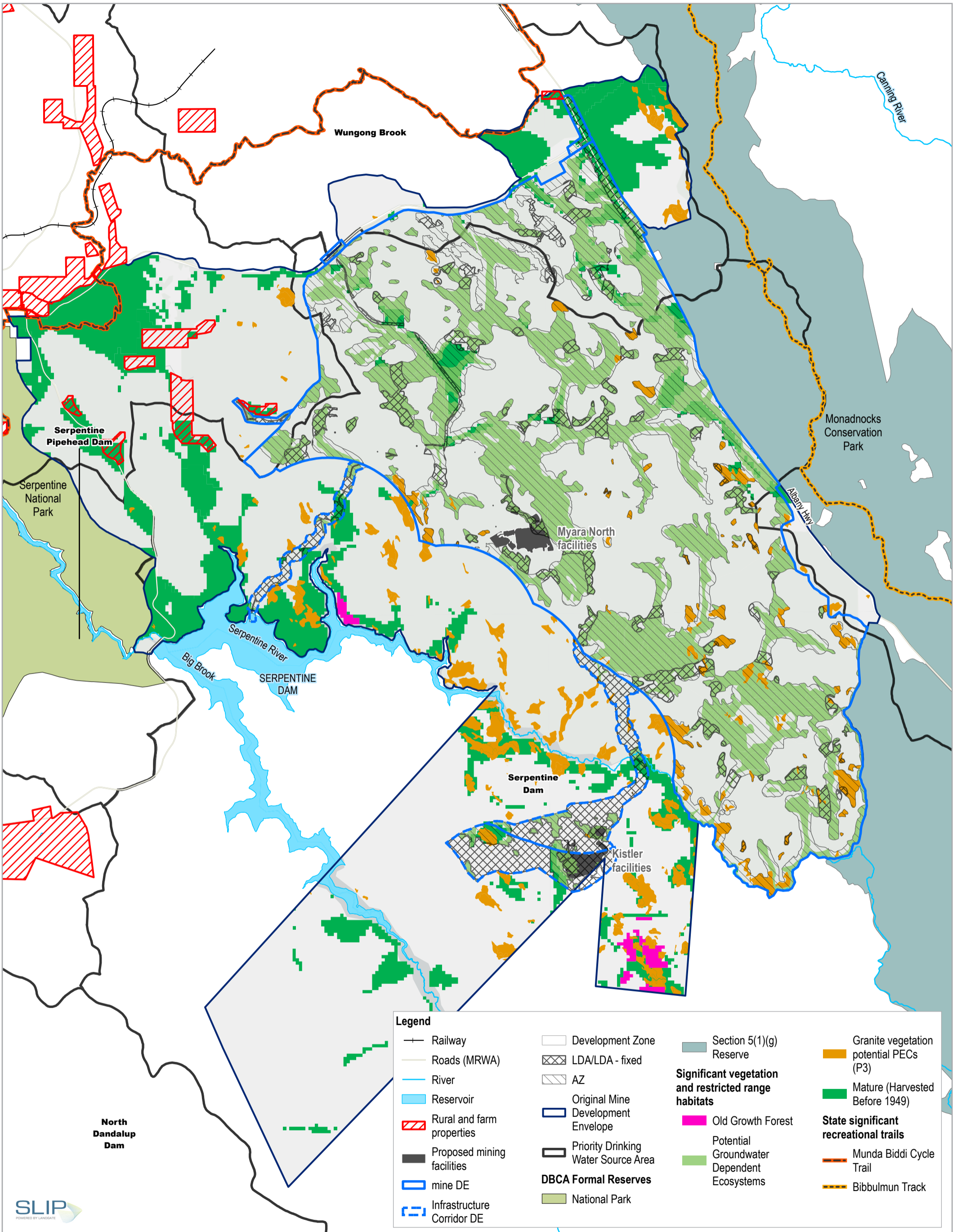
Table 4.5 Mine avoidance and development zones – breakdown by area

Zone	Myara North			Holyoake			O'Neil	Proposal DE total		
	Area within mine DE (ha)	Area within ICDE (ha)	Total (ha)	Area within mine DE (ha)	Area within ICDE (ha)	Total (ha)	Area within mine DE (ha)	Area within mine DE (ha)	Area within ICDE (ha)	Total (ha)
Avoidance Zone	4,143	152	4,295	1,550	-	1,550	2,084	7,777	152	7,929
Low Disturbance Area	715	548*	1,262	400	1198	1,598	486	1,601	1746	3,347
Low Disturbance Area - fixed	1	8	9	8	5	13	2	11	13	24
Mine Development Zone	5,138	-	5,138	4,463	-	4,463	2,998	12,599	0	12,599
DE total	9,997	708	10,705	6,421	1,203	7,624	5,571	21,989	1911	23,900

* 243 ha of the ICDE LDA is existing cleared land at Kisler. 305 ha of the ICDE LDA is uncleared land that may be subject to disturbance

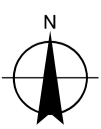
Table 4.6 Mine avoidance and development zones – breakdown by proportion

Zone	Myara North			Holyoake			O'Neil	Proposal DE total		
	Proportion of mine DE (%)	Proportion of ICDE (%)	Proportion of total (%)	Proportion of mine DE (%)	Proportion of ICDE (%)	Proportion of total (%)	Proportion of mine DE (%)	Proportion of mine DE (%)	Proportion of ICDE (%)	Proportion of total (%)
Avoidance Zone	41.4	21.5	40.1	24.1	-	20.3	37.4	35.4	8.0	33.2
Low Disturbance Area	7.2	77.4	11.8	6.2	99.6	21.0	8.7	7.3	91.4	14.0
Low Disturbance Area - fixed	0.0	1.1	0.1	0.1	0.4	0.2	0.0	0.1	0.7	0.1
Mine Development Zone	51.4	-	48.0	69.5	-	58.5	53.8	57.3	-	52.7
DE total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0



Legend			
	Railway		Development Zone
	Roads (MRWA)		LDA/LDA - fixed
	River		AZ
	Reservoir		Original Mine Development Envelope
	Rural and farm properties		Priority Drinking Water Source Area
	Proposed mining facilities	DBCA Formal Reserves	
	mine DE		National Park
	Infrastructure Corridor DE		Section 5(1)(g) Reserve
		Significant vegetation and restricted range habitats	
			Old Growth Forest
			Potential Groundwater Dependent Ecosystems
			Granite vegetation potential PECs (P3)
			Mature (Harvested Before 1949)
		State significant recreational trails	
			Munda Biddi Cycle Trail
			Bibbulmun Track

Scale: 1:75,000 at ISO A3
 0 0.5 1 1.5 2
 Kilometres



Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 50

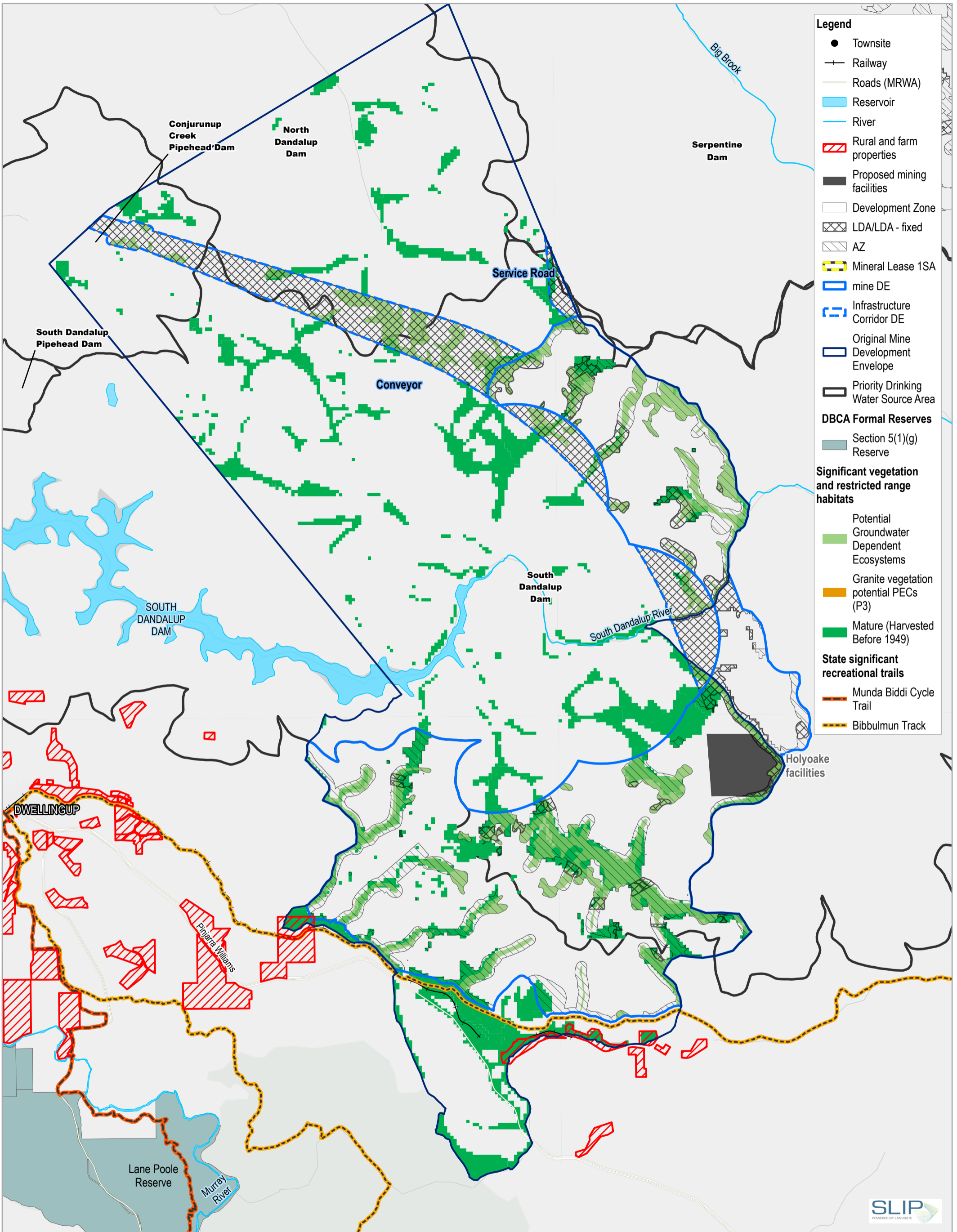
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 Revision No. 3
 Date 07/03/2025

**Impact Avoidance Overview -
 Myara North**

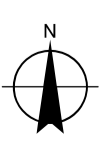
FIGURE 4-1

Light Gray Base: Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS.



- Legend**
- Townsite
 - +— Railway
 - Roads (MRWA)
 - Reservoir
 - River
 - ▨ Rural and farm properties
 - Proposed mining facilities
 - Development Zone
 - ▩ LDA/LDA - fixed
 - ▧ AZ
 - ▤ Mineral Lease 1SA
 - ▭ mine DE
 - ▨ Infrastructure Corridor DE
 - ▭ Original Mine Development Envelope
 - ▭ Priority Drinking Water Source Area
 - DBCFA Formal Reserves**
 - ▭ Section 5(1)(g) Reserve
 - Significant vegetation and restricted range habitats**
 - ▭ Potential Groundwater Dependent Ecosystems
 - ▭ Granite vegetation potential PECs (P3)
 - ▭ Mature (Harvested Before 1949)
 - State significant recreational trails**
 - ▭ Munda Biddi Cycle Trail
 - ▭ Bibbulmun Track

Scale: 1:75,000 at ISO A3
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 Kilometres
 Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 50



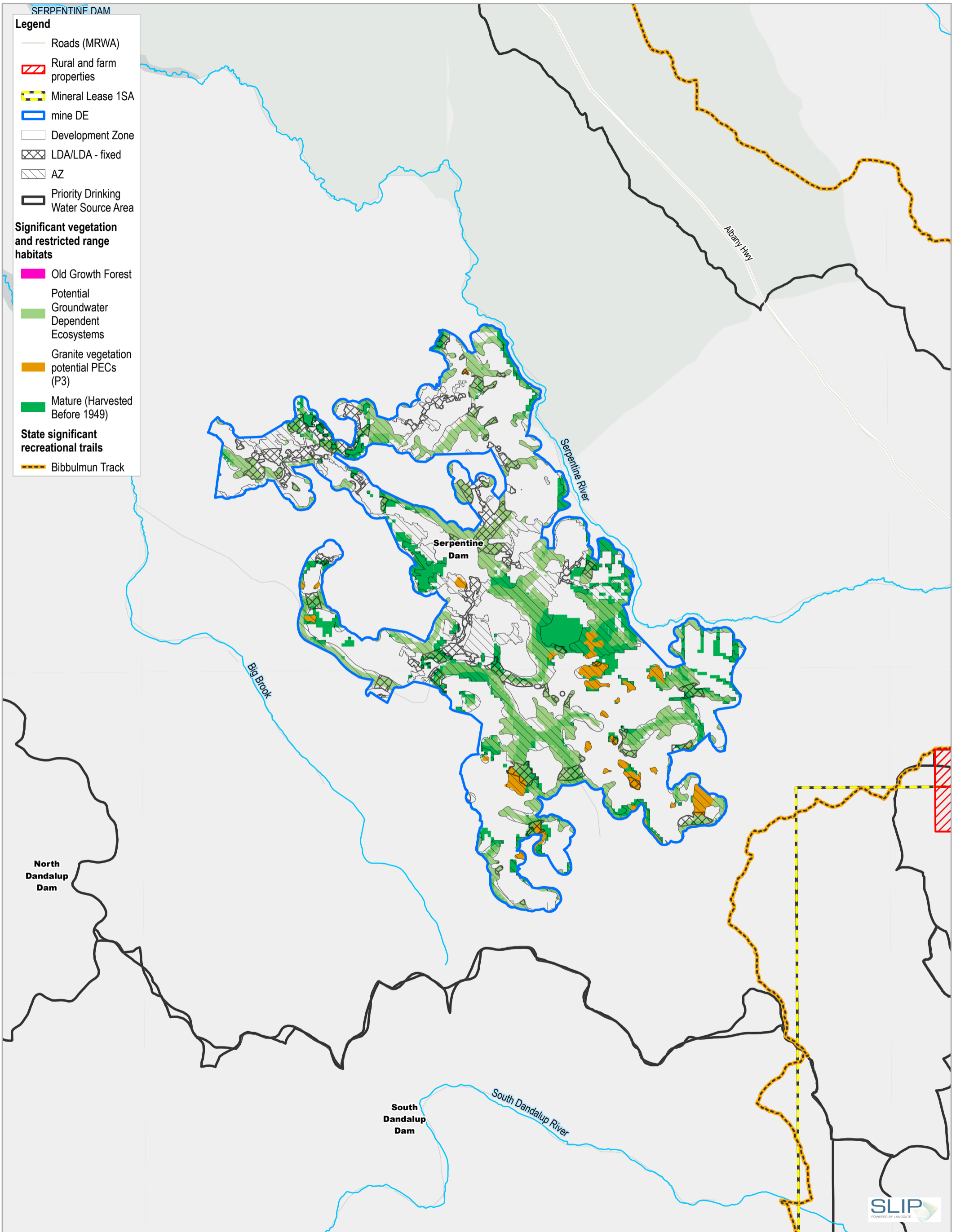
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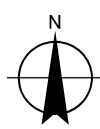
**Impact Avoidance Overview -
 for Holyoake**

FIGURE 4-2

Light Gray Base: Esri, TomTom, Garmin, Foursquare, METINASA, USGS
 Light Gray Reference: Esri, TomTom, Garmin, Foursquare, METINASA, USGS



Scale: 1:75,000 at ISO A3
 0 0.5 1 1.5 2
 Kilometres



Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 50

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Impact Avoidance Overview -
 O'Neil

FIGURE 4-3

Data source: Light Gray Base: Esri, TomTom, Garmin, Foursquare, METINASA, USGS
 Light Gray Reference: Esri, TomTom, Garmin, Foursquare, METINASA, USGS

4.3.3.3 *Pre-clearance studies and targeted avoidance*

As recognised by the Appeals Committee considering the Worsley Expansion Proposal (Office of the Appeals Convenor 2024, pp24), Alcoa considers it reasonable to collect survey information in real-time to support operational decision-making. As is detailed in Alcoa's operational environmental management plans (see Section 2.3.2), ecological surveys and hydrological investigations will be undertaken at least six months and up to two years ahead of clearing for mining operations. These will be focused on disturbance footprints as detailed in the current mine plan at the time. The operational environmental management plans will define how the avoidance and minimisation measures that will be deployed in response to the data gathered at that time.

The targeted avoidance areas and measures within MDZ and LDA will include as a minimum:

Flora and vegetation / terrestrial fauna

- avoid clearing of restricted range vegetation types, including:
 - granite outcrop vegetation, which is a potential occurrence of a Priority Ecological Community
 - open woodland of *Eucalyptus wandoo*
- avoid clearing threatened flora.
- avoid clearing more than two per cent of the known population of priority flora, where the known population is less than 100 individuals, or otherwise avoid clearing more than ten per cent of the known population.
- avoid clearing recorded active Chuditch nursery dens
- avoid clearing known or suitable Black Cockatoo nesting trees, unless necessary to construct Critical Infrastructure.
- avoid clearing known nighttime Black Cockatoo roosting trees.
- avoid clearing within 100m buffer of mapped Western Ringtail Possum population extent.
- avoid populations of Carter's Freshwater Mussel.

Inland waters

- avoid developing pits in areas with an average slope greater than 16 per cent.
- limit open area (i.e. cleared but rehabilitation not yet completed) to no more than 30 per cent of subcatchment area, reconciled on an annual basis.

Social surroundings

- avoid recorded Aboriginal heritage sites

4.3.3.4 *Outcomes of avoidance measures*

The avoidance of restricted range vegetation types and limited crossing of streams and swamps is expected to be highly effective to protecting key environmental values within the mine DEs. Based on the mine DE's AZs, the Proposal is anticipated to avoid the following within the Mine DE (see Sections 5.4.2.2, 5.5.1 and 6.4.2.6):

- at least 89 per cent of granite outcrop vegetation (R and G Vegetation Types)
- at least 83 per cent of swamps (A dominant Vegetation Types)
- at least 84 per cent of stream zone vegetation (C dominant Vegetation Types)
- at least 84 per cent of the mapped stream length.

The above estimates are conservative, assuming all sensitive values within the LDAs are disturbed, whereas only a portion are expected to be actually disturbed.

The predicted high level of avoidance within the Myara North DE is consistent with, and empirically validated by, the protection of these vegetation types in the Huntly Mine to date,

which has involved the same mining and haulage method over similar geology and landforms. Vegetation mapping over 53,532 ha of the existing and historic mine regions of the Huntly Mine indicates that the clearing from 1989 to 2022 has avoided:

- more than 99 per cent of granite outcrop vegetation
- more than 98 per cent of swamps
- more than 98 per cent of stream zone vegetation.

Clearing in the Huntly Mine since 1972 has avoided approximately 97 per cent of the mapped stream length within the mine regions, including 96 per cent of the mapped third and fourth order streams.

Based on the AZ coverage, the Proposal is expected to avoid approximately 1,947 ha or 68 per cent of mature age forest within the Mine DE. Combined with the post-referral amendment of the Mine DE, the Proposal is expected to avoid a total of 4,772 ha of mature age forest. The Proposal will avoid all mapped old-growth forest and any old growth forest patches identified during pre-clearance surveys (see Section 5.5.1).

The avoidance of restricted range vegetation types, streams, old growth and mature age forest is therefore predicted at a high confidence and will protect the associated significant vegetation, flora and fauna populations, contributing to the maintenance of the ecological integrity of the NJF.

Where direct impacts to known Aboriginal heritage sites cannot be avoided, Alcoa will seek the free, prior and informed consent of Traditional Owners, document that consent and any mitigating actions agreed and seek Ministerial consent under section 18 of the *Aboriginal Heritage Act 1972*.

4.3.4 Disturbance budget and apportionment

As detailed in Section 1.4 and the Proposal Content Document, the Proposal will disturb up to 7,500 ha across the Mine DE, with no disturbance proposed within the Refinery DE. This disturbance will only occur with the MDZ and LDA within each mine DE.

For the purposes of this ERD, Alcoa has apportioned the disturbance budget across the MDZ and LDA of each Mine DE as presented in Table 4.7 and Table 4.8. The apportionment is conservative as it apportions a greater proportional clearing within the LDAs, which is greater than is expected to actually occur. For example, the LDA corridors for haul roads across valleys covered by the AZ are typically about 200-250 m in width, whereas actual disturbance for haul roads is typically 50-70 m or about a quarter to a third of the LDA.

Within the Infrastructure Corridor DEs the disturbance area is a conservative estimate of what is required to accommodate the planned haul roads and infrastructure based on designs that are currently at various stages of development. Within the mine DEs the disturbance area is sufficient to ensure efficient mining and optimal resource recovery in terms of pit development and supporting haul roads and infrastructure.

The mine plan recognises that future pre-clearance surveys or consultations may identify further environmental, social or heritage constraints within the MDZs and LDAs that must be avoided, e.g., Black Cockatoo nesting trees, Aboriginal heritage. In response to this, the mine plan is adaptive, in that disturbance can occur anywhere within the unconstrained areas of the MDZs and LDAs up to the corresponding budget hectare amount. Alcoa anticipates that the Proposal will be conditioned such that across the three mine DEs the total disturbance within the MDZs will be limited to 4,749 ha and within the LDAs 2,751 ha¹ (totalling 7,500 ha).

¹ This extent of LDA clearing is worst case, since it is anticipated that clearing in LDAs will in fact be limited to that necessary to build the finalised haul road or infrastructure alignment through the LDA.

For the purposes of the accredited assessment under the EPBC Act of the Proposal's potential impacts to MNES in the Myara North and Holyoake DEs (i.e. excluding the O'Neil DE), Alcoa anticipates that the Proposal will be conditioned by the Commonwealth Minister of the Environment such that across these two mine DEs the total disturbance within the MDZ will be limited to 4,175 ha and within the LDA limited to 2,263 ha (totalling 6,438 ha).

4.3.5 Numerical modelling

The estimation of indirect impacts within the Mine DE has incorporated numerical modelling for the following:

- groundwater mounding, stream flow and stream salinity (Sections 8.4.3 and 8.4.4)
- sediment discharge and reservoir hydrodynamics (Section 8.4.9.3)
- air quality (Sections 9.3.3.1 and 9.4.3)
- noise (Section 12.4.2).

In each case, the numerical modelling has used conservative assumptions, which improve the confidence in estimated impacts, given the uncertainty in the actual footprint of mining operations within the Mine DE. The assumptions are documented for each model in the supporting technical reports in Appendix B and include adopting worst-case conditions for meteorology and flood events, catastrophic and unprecedented failure of mine drainage systems, and worst-case operational scenarios for mining.

Where available, the numerical modelling has been compared with historic environmental data (e.g. reservoir water quality monitoring, hydrological and salinity studies in catchments subject to past bauxite mining) to provide further evidence of the likelihood of significant impacts occurring (Sections 8.4.3, 8.4.4 and 8.4.9.3).

Table 4.7 Proposal disturbance budget breakdown of areas by zones

Zone	Myara North			Holyoake			O'Neil	Proposal Mine DE total		
	Area within mine DE (ha)	Area within ICDE (ha)	Total disturbance within DE (ha)	Area within Mine DE (ha)	Area within ICDE (ha)	Total disturbance within DE (ha)	Area within mine DE (ha)	Area within Mine DE (ha)	Area within ICDE (ha)	Total disturbance within Mine DE (ha)
Avoidance Zone	-	-	-	-	-	-	-	-	-	-
Low Disturbance Area (including LDA fixed)	716	313	1,029	408	826	1,234	488	1,612	1,139	2,751
Mine Development Zone	2,190	-	2,190	1,985	-	1,985	573	4,748	-	4,748
DE total	2,906	313	3,219	2,393	826	3,219	1,062	6,361	1,139	7,500

Table 4.8 Proposal disturbance budget breakdown as a proportion of zones

Zone	Myara North			Holyoake			O'Neil	Proposal Mine DE total		
	mine DE Proportion of zone (%)	ICDE Proportion of zone (%)	Total DE Proportion of zone (%)	mine DE Proportion of zone (%)	Proportion of zone (%)	Proportion of zone (%)	mine DE Proportion of zone (%)	Mine DE Proportion of zone (%)	ICDE Proportion of zone (%)	Total Proportion of zone (%)
Avoidance Zone	-	-	-	-	-	-	-	-	-	-
Low Disturbance Area (including LDA fixed)	100.0	56.3	81.0	100.0	68.7	76.6	100.0	100.0	64.8	81.6
Mine Development Zone	42.6	-	42.6	44.5	-	44.5	19.1	37.7	-	37.7
DE total	29.1	44.2	30.1	37.3	68.7	42.2	19.1	28.9	59.6	31.4

4.4 Development of Biodiversity Indicators and Assessment and Monitoring Framework

4.4.1 Background context

The ESD Addendum (EPA 2022) required the development of Biodiversity Indicators (BIs) that could be used to assess whether impacts of and environmental outcomes from the Proposal are likely to be consistent with the ongoing ecological integrity of the NJF.

The EPA define 'ecological integrity' in the context of their objectives for Flora and Vegetation and Terrestrial Fauna (EPA 2016a, EPA 2016b) as "...the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements."

The NJF, as it is referred to in this document, is the subregion as described by the Interim Biogeographic Regionalisation of Australia (IBRA). The NJF subregion comprises a total of approximately 1.90 million ha and is broadly characterised by Jarrah (*Eucalyptus marginata*) or djarraly (Noongar language) forest on ironstone gravels and Marri-Wandoo (*Corymbia calophylla* - *Eucalyptus wandoo*) woodlands on loamy soils, with sclerophyll understoreys. The NJF subregion retains native vegetation over approximately 1.11 million ha (58 per cent) (GoWA 2019). Approximately 69 per cent of the remaining vegetation is within DBCA managed lands in the west and south (GoWA 2019). Substantial clearing has occurred for agriculture in the north and east, as well as urban rural residential areas in the Perth Hills (e.g. Gidgegannup, Mundaring, Roleystone, Kalamunda)

The key threats to the NJF subregion are listed in the Forest Management Plan (FMP) 2024-2033 (Conservation and Parks Commission 2023) as follows:

- **Climate change** - Increasing temperatures, altered rainfall patterns, and other effects of climate change can have profound impacts on the Northern Jarrah Forest. Climate change can influence vegetation dynamics, alter species distributions, and affect the timing of ecological events like flowering or migration.
- **Habitat loss and fragmentation** - Permanent loss of native vegetation for agriculture, urban development, and infrastructure projects can lead to the loss and fragmentation of the forest habitat. This reduces the available area for native species and disrupts ecological processes.
- **Weeds and pest animals** - Introduction and establishment of invasive plant and animal species can outcompete native species, disrupt ecosystem processes, and alter habitat suitability in the Northern Jarrah Forest. Invasive species can negatively impact plant diversity, disrupt food webs, and alter nutrient cycling.
- **Altered hydrological regimes** – Changes to the patterns of water flow, distribution, and availability within the Northern Jarrah Forest are a key threat impacting water availability to plants, influence the moisture content of vegetation and soil, which in turn affects fire behaviour, can create opportunities for invasive plant species to establish and spread and can alter the movement of nutrients within the ecosystem.
- **Inappropriate fire regimes** - Changes in fire regimes, both natural and human-induced, can affect the ecological dynamics of the Northern Jarrah Forest. Inappropriate fire management practices, such as frequent or intense fires, can disrupt natural regeneration, impact species composition, and alter vegetation structure.

The Recovery Plans for the Matters of National Environmental Significance known to be present in the NJF, list the following additional threats:

- gaps in knowledge
- feral animal predation.

Together these threats have influenced the determination of the BIs.

4.4.2 Implementation

Alcoa notes the following EPA recommendation made in its Worsley Mine Expansion – Revised Proposal assessment report (Report 1768, 2024):

“The EPA recommends a whole-of-government approach to examine the known and unknown pressures on the forest ecosystem, identify and prioritise knowledge gaps, and make recommendations to the State Government on long term management of the NJF.”

Together with the commitment of the WA Government’s 2024-2033 Forest Management Plan, a Forest Health Monitoring Program will be implemented that will measure trends in key biodiversity indicators.

Alcoa therefore wishes to share with relevant stakeholders the work it has completed to develop BIs and a monitoring framework, and the findings of the Peer Review of this work, see Appendix B24. Alcoa promotes the establishment of a working group consisting of key stakeholders to collaboratively further develop adequate, scientifically robust and appropriate biodiversity indicators to assess and monitor the ongoing ecological integrity of the Northern Jarrah Forest. Alcoa would then advocate for a whole-of-government approach to the implementation of a BI monitoring program.

4.4.3 Guidance and development

Alcoa conducted a literature review, investigating the use of BIs across Australia and internationally. This review indicated that no specific BIs were currently in active use within Western Australia and more specifically within the NJF subregion. Given this, Alcoa developed project specific BIs with reference to the following documents:

- NSW Biodiversity Indicator Program (BIP): a peer-reviewed method developed by the NSW Govt & CSIRO to collect, monitor & assess the status and trends of biodiversity in NSW
- Measuring biodiversity and ecological integrity in NSW - Method for the Biodiversity Indicator Program (OEH, and CSIRO. 2019).
- Forest Management Plan 2024 – 2033: in particular, the Foundation 2 (Biodiversity Conservation) and Foundation 3 (Forest Health & Climate Resilience) Performance measures.
- The Montreal Process - Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montreal Process Working Group 2015).
- A framework for developing mine-site completion criteria in Western Australia (Young et al 2019).

Drawing on this guidance, 12 BIs for the ecological integrity of the NJF are proposed. Alcoa considers that the measurement and monitoring of these BIs would demonstrate the ongoing ecological integrity of the NJF.

The development of the BIs has considered the following EPA environmental factors and their corresponding environmental objectives:

- Terrestrial Fauna (EPA 2016a)
- Flora and Vegetation (EPA 2016b)
- Terrestrial Environmental Quality (EPA 2016c)

- Inland Waters (EPA 2018)
- Social Surroundings (EPA 2016d).

Two environmental factors, Air Quality and Greenhouse Gas Emissions, are not directly assessed by the BIs. This decision was made as these two factors are not directly linked to the ongoing ecological integrity of the NJF.

4.4.4 Initial list of BIs

The outcome of the development process discussed above is 12 BIs; these are summarised below and presented in full in Appendix B24. The rationale for each BI is set out in Section 4.4.5. The BIs are presented in four 'groups'.

Group 1: Regional conservation indicators are designed to measure the ecological integrity of the NJF at a regional scale. These indicators are able to measure extents beyond the control of Alcoa and are designed to reflect the potential for the NJF to support key ecological values.

Group 2: Forest ecosystems are based around habitat and ecosystem level extents, with a scale centred around a local scale. These indicators are designed to measure changes to ecosystems that may indicate negative impacts from either operations or external pressures.

Group 3: Targeted bio-indicators are based around fauna assemblages and presence of threatened fauna taxa. These indicators are intended to measure localised small scale changes in response to impacts from operations or external pressures. These indicators are designed to detect changes at a smaller scale than may be possible at an ecosystem level.

Group 4: Threatening processes are based around three of the key threats to the ecological integrity of the NJF. These indicators are intended to measure the impact of external pressures on ecological integrity of the NJF within current Alcoa mining operations. Changes to these external pressures may require alteration to mine planning, rehabilitation prescriptions or other operational environmental management.

The 12 BIs are listed below:

Group 1: Regional conservation

1. Areas within the NJF covered by a Protective Mechanism
2. Disturbance to vegetation communities of conservation significance

Group 2: Forest ecosystems

3. Ecological condition of native vegetation
4. Vegetation health in shallow groundwater zones
5. Ecological condition of waterways
6. Ecological connectivity of native vegetation

Group 3: Targeted bio-indicators

7. Avifauna
8. Ground fauna presence/absence
9. Forest red-tailed black cockatoo population estimates

Group 4: Threatening processes

10. Inappropriate fire regimes
11. Extent and impact of invasive species
12. Dieback infection

4.4.5 Rationale for each BI

4.4.5.1 Regional conservation indicators

Areas within the NJF covered by a Protective Mechanism

This BI was developed to assess the extent of the NJF IBRA subregion that is currently and proposed to be covered by a Protective Mechanism. In the context of this indicator, 'Protective Mechanism' is defined as:

- lands secure for conservation (National Parks, Nature Reserves, Conservation Parks and any other crown reserve that have "Conservation" as part of the reserve purpose)
- land with a conservation covenant placed over it.

Areas of the NJF that have a Protective Mechanism preventing clearing or development can assist in safeguarding biological diversity and restricted ecosystem types. This BI may identify vegetation associations (as a potential surrogate for identified environmental values under the Flora and Vegetation and Terrestrial Fauna Factor Guidelines) that are underrepresented within the areas of the NJF covered by Protective Mechanisms. The EPA is of the view that vegetation can be an effective surrogate for ecological processes and the diversity of interactions in terrestrial ecosystems (EPA 2016a).

This BI aligns with the Montreal Process (indicator 4.1 – protective function) and the NSW BIP (indicator 4.1a – Areas managed for conservation in perpetuity and indicator 4.1b – Areas managed for conservation under formal or informal agreements).

This BI is intended to be assessed across the entirety of the NJF as it would capture changes across the largest spatial area.

Disturbance to vegetation communities of conservation significance

This BI, aligned with the Flora and Vegetation and Terrestrial Fauna Factor guidelines, is proposed to provide an indication of the ability of the NJF to provide specialised ecological function and processes to support flora and fauna species (restricted range vegetation types limited distribution vegetation, TECs, PECs, wetlands, vegetation types known to contain threatened flora, old growth forest). Conservation of vegetation communities with high ecological value helps preserve the diverse array of plant species found in the Northern Jarrah Forest. Different vegetation communities also perform essential ecological functions in the Northern Jarrah Forest, specifically providing specialised habitats for various flora and fauna species.

Where changes occur beyond a critical threshold, forest ecosystem health and vitality may be significantly altered and a forest's ability to recover could be reduced or lost (Montréal Process Working Group 2015). The outcomes of the monitoring of this proposed BI would inform the formulation of management strategies, mitigating risks to the ecological integrity of the NJF.

This BI is based on the NSW BIP (indicator 1.1b – Expected existence of listed threatened ecological communities). This BI deviates from the NSW BIP as the BI uses on-ground clearing data to determine impacts to ecological communities of conservation significance at a local scale (within the Mine DE). While the monitoring scale is local, the conservation of the vegetation communities of conservation significance can be compared to regional data.

4.4.5.2 Forest ecosystem indicators

Ecological condition of native vegetation

This BI is aligned with the Flora and Vegetation and Terrestrial Fauna Factor guidelines and is proposed to provide an indication of the ability of the NJF's ecological functions and processes to recover from or adapt to disturbances caused by mining operations. This BI would be measured using structure and composition metrics (native vegetation density, cover and richness) to detect changes in vegetation condition as a result of impacts from mining

operations. Structure and composition were selected in lieu of other metrics due to their ability to be sampled at a large scale. Structure and composition are also related to other measures of ecological condition including presence of invasive species, forest disease and fragmentation; changes in composition could indicate a vulnerability to these impacts. Changes could also indicate that invasive species, forest disease or fragmentation have already caused a reduction in ecological condition, potentially impacting the ecological integrity of the NJF.

Where changes occur beyond a critical threshold, forest ecosystem health and vitality may be significantly altered and a forest's ability to recover could be reduced or lost (Montréal Process Working Group 2015). The outcomes of the monitoring of this proposed BI would inform the formulation of management strategies, mitigating risks to the ecological integrity of the NJF.

This BI is based on the Montreal Process (indicator 3.a - Area and percent of forest affected by biotic processes and agents (e.g. disease, insects, invasive species beyond reference conditions, and indicator 3.b – Area and percent of forest affected by abiotic agents e.g. fire, storm, land clearance, beyond reference conditions), and NSW BIP (indicator 3.1a – Ecological condition of terrestrial vegetation). This BI deviates from the Montreal Process and NSW BIP as it uses four sub-indicators (Appendix B24) to detect changes in condition. This BI would be measured at a local scale through a combination of remote sensing and on-ground data collection.

This BI would be assessed across a mine region. This scale has been chosen as it represents the area most likely to be impacted by mining operations. Impacts detected at greater distances will not have the supporting data available to conduct a causal analysis.

Vegetation health in shallow groundwater zones

This BI would measure potential impacts to vegetation and fauna habitats that interact with groundwater within a mine region. Mining operations will alter the natural hydrogeological regimes, potentially impacting areas of shallow groundwater (3-6 metres below ground level) that interact with and provide supporting functions to the riparian vegetation health and aquatic habitats.

Current groundwater monitoring (water quality and levels) occurs as part of mining planning, operation and rehabilitation. This BI is designed to supplement the abiotic monitoring, to assist with determining potential impacts to the NJF ecosystem and values for inland waters, terrestrial fauna and health and resilience of native flora and vegetation occurring within the NJF.

This BI has not been based on an existing peer-reviewed document, but is proposed to be included given the high value of habitats that are susceptible to changes in shallow groundwater levels, and changes in hydrological regimes are considered a key threat from mining activities to the NJF (Conservation and Parks Commission 2023).

This BI would be assessed across a mine region, within areas of shallow groundwater. This scale has been chosen as it represents the area that will show impacts from proposed mining operations.

Waterway health

This BI and its proposed sub-indicators (water way flow rate and water way flow quality) were developed to measure potential impacts to vegetation health, terrestrial environmental quality, and terrestrial and aquatic fauna habitats that interact with surface water within a mine region. Mining operations will alter hydrological regimes and potentially mobilise sediment, increase salinity or release other contaminants that may pose a potential threat to water quality and ecosystem health.

This BI would be measured using surface water quantity (i.e. flow rate) and surface water quality. This recognises that while the NJF ecosystems are dominated by terrestrial vegetation, waterways provide a network of seasonal riparian and aquatic habitats and functions that contribute to the ecological integrity of the NJF.

This BI is based on the NSW BIP (indicator 3.2d – Inappropriate hydrological regimes). This BI deviates from the NSW BIP as the BI initially uses water flow and water quality to indicate if potential impacts could occur rather than only measuring impacts after they occur.

This indicator would be assessed at locations determined during the mine planning phase. Monitoring would occur in areas upstream and downstream of:

- planned activity (representing baseline)
- active pits
- rehabilitated pits (<5 years old).

Historical surface water monitoring data recorded at locations downstream of existing mining and rehabilitation would be used to inform and guide the location of monitoring sites.

Monitoring would be established at least 24 months prior to ground disturbance to establish baseline water quality objectives in accordance with ANZG 2018.

Ecological connectivity of native vegetation

This BI, aligned with the Flora and Vegetation and Terrestrial Fauna Factor guidelines, is designed to measure and assess any habitat fragmentation resulting from clearing to enable mining operations. Fragmentation is a threat to ecosystem diversity as it results in decreased connectivity and ecosystem resilience. Fragmentation can lead to the isolation and loss of species and gene pools, degraded habitat quality, and a reduction in the forest's ability to sustain natural processes (Montréal Process Working Group 2015).

This BI is closely aligned to the NSW BIP (indicator 3.1b – Ecological connectivity of terrestrial vegetation) and is scalable.

This BI would be assessed through measurement of a fragmentation index, adapted from the NSW BIP (Appendix B24) across the Mine DE. This assessment extent has been chosen as it represents the area most likely to be impacted by fragmentation arising from mining operations within the Mine DE.

4.4.5.3 Targeted bio-indicator groups

Avifauna

This BI is proposed to provide an indication of the ability of the NJF's ecological functions and processes to recover from or adapt to disturbances caused by mining operations, using avifauna as surrogates for structural and compositional change to habitat.

As a group, the distribution and ecology of birds in south-west WA are well understood. They are particularly useful indicators of forest structure, as most species are not impacted by feral predation. They are conspicuous and readily identified without collection, allowing extensive and cost-effective survey.

The following sub-indicators are proposed:

1. Avifauna assemblages using appropriate multivariate statistical analyses
2. Selected bird species – presence/abundance:
 - a. Ringneck Parrot (widespread, seed and cambium eater, hollow nesting)
 - b. Red-capped Parrot (widespread, seed and cambium eater, hollow nesting)
 - c. Splendid fairy-wren (streamzone) [Abbott 1999]

- d. Red-winged fairy-wren (streamzone) [Abbott 1999]
 - e. White-breasted robin (streamzone) [Abbott 1999]
 - f. Western yellow robin (upland open forest, responsive to fragmentation) [Abbott 1999, Craig et al 2015]
3. Selected bird species – absence:
- a. Singing Honeyeater (common in partially cleared forest, gardens, and often marked preference for isolated shrubs or thickets) [Abbott 1999]
 - b. Red-capped robin (disturbed or sparsely wooded habitats) [Abbott 1999]
 - c. Willie Wagtail (disturbed or sparsely wooded habitats) [Abbott 1999]
 - d. Magpie lark (disturbed or sparsely wooded habitats) [Abbott 1999]
 - e. White-winged triller (disturbed or sparsely wooded habitats, breeds along watercourses) [Abbott 1999]
 - f. Grey Butcherbird (disturbed or sparsely wooded habitats) [Abbott 1999]

This BI would be assessed across a mine region. This scale has been chosen as it represents the area most likely to be impacted by mining operations. Impacts detected at greater distances will not have the supporting data available to conduct a causal analysis.

Ground fauna presence/absence

This BI is proposed to provide an indication of the ability of the NJF's ecological functions and processes to recover from or adapt to disturbances caused by mining operations, using ground fauna presence to measure faunal return post mining impact.

This BI aligns with the Montreal Process (indicator 1.3b - Population levels of selected representative forest associated species to describe genetic diversity) and NSW BIP (indicator 2.3a – species trends).

This BI would be assessed across both current and previously mined areas of NJF, in alignment with the current Alcoa Long Term Fauna Monitoring (LTFMP) scope. This monitoring would capture current impacts and assess species habitation within older rehabilitation areas.

Forest red-tailed black cockatoo population estimates

The Forest red-tailed black cockatoos have been considered for inclusion as an avifauna indicator species due to their potential sensitivity to reduction in habitat quality, particularly related to the suitable breeding habitat and foraging resources of the NJF. These species have a large range, and as a consequence, developing a suitable monitoring program to detect changes in population trends resulting from impacts within a mine region is difficult. Alcoa are developing a monitoring methodology that is suitable for black cockatoos. The monitoring methodology will be built around an adaptive framework as population monitoring for black cockatoos at this scale has not been undertaken before. Throughout the life of mine, this monitoring method will be reviewed, and changes made where improvements can be made.

4.4.5.4 Threatening Processes

Inappropriate fire regimes

This BI, aligned to the Flora and Vegetation, Terrestrial Fauna, Inland Waters, and Social Surroundings Factor Guidelines, assesses the impacts of mining operations, specifically the rehabilitation of cleared vegetation, on the NJF's resilience to fire, within the context of a drying climate. Climate change is affecting landscape dryness and fuel availability, and the frequency and intensity of extreme fire weather is expected to increase (Conservation and Parks

Commission 2023). A consideration of the impact of rehabilitation methods on the forest's resilience to fire is considered an appropriate measure of ecosystem resilience.

A monitoring method is currently under development, with no data currently available to determine changes to fire impacts and ultimately the appropriateness of the current fire regime. The monitoring methods would require development with DBCA staff to understand current and future fire management practices, and how they may interact with a drying climate.

This BI is based on the NSW BIP (indicator 3.2c - inappropriate fire regimes) and Montreal Process (indicator 3.b - Area and percent of forest affected by abiotic agents e.g. fire, storm, land clearance, beyond reference conditions). This BI deviates from the NSW BIP and Montreal Process indicators as there is currently insufficient data available to determine inappropriate fire regimes within the NJF and how these may affect the ecological integrity of the subregion.

This BI would be assessed across representative previously mined areas of the NJF, in order to determine the impacts of, and arising from, past rehabilitation.

Extent and impact of invasive species

This BI identifies the potential impact that biotic processes and agents, i.e. weeds and feral animals, have on the NJF ecosystem. Where change due to these agents and processes occurs beyond a critical threshold, NJF ecosystem health and vitality may be significantly altered and its ability to recover could be reduced or lost (Montréal Process Working Group 2015).

Monitoring this BI may help to determine the current and potential future impacts of invasive species and inform the preparation of management strategies to mitigate risk to the NJF's ecosystem.

This BI is based on the NSW BIP (indicator 3.2e - Invasive species - pests, weeds, disease) and Montreal Process (indicator 3.b - Area and percent of forest affected by abiotic agents e.g. fire, storm, land clearance, beyond reference conditions). This indicator deviates from the Montreal Process and NSW BIP as it uses three sub-indicators (native plant species composition, invasive species richness and feral animal predation) to detect changes and impacts of invasive species. The three sub-indicators would provide a more appropriate measurement at a local scale.

This BI would be assessed across a mine region. This assessment extent has been chosen as it represents the area most likely to be impacted by mining operations. Impacts detected at greater distances will not have the supporting data available to conduct a causal analysis.

Dieback infection

This BI identifies the potential impact that *Phytophthora cinnamomi* dieback has on the NJF ecosystem. Phytophthora dieback is the most significant plant disease affecting values in the planning area, with many native flora and threatened species considered susceptible. Where change due to this pathogen occurs, there can be severe negative impacts on biodiversity and forest health (Conservation and Parks Commission 2023).

Monitoring this BI may help to determine the current and potential future impacts of this pathogen and inform the implementation of existing and emerging technologies for controlling the spread and impact of dieback.

This BI is intended to be assessed across the entirety of the NJF as it would capture changes across the largest spatial area.

4.4.6 Assessment and monitoring framework

Fundamental elements for a BI assessment and monitoring framework have been developed. The proposed BIs could be used to assess and monitor potential impacts (distinguished between mining operations and other threatening processes) across the whole of life of a mining operation, and provide input into ongoing and adaptive management, as outlined in Table 4.9, and Figure 4-4.

Table 4.9 Biodiversity Indicators and their opportunity to influence on mine life phases

Mining life phase	Influence of Biodiversity Indicators
Planning	<ul style="list-style-type: none"> • Guide mine planning, avoidance zones, and future impacts • Inform pre-clearance methods and additional baseline survey requirements • To provide assurance to the public that potential impacts will be identified and used to inform mitigative actions, ongoing planning and rehabilitation
Operations (including pre-mining, mining and rehabilitation)	<ul style="list-style-type: none"> • Provide inputs into adaptive management • Provide inputs into regional scale research programs • Guide development of additional monitoring and assessment to fill knowledge gaps • Guide development and improvement of rehabilitation methods and techniques
Closure	<ul style="list-style-type: none"> • Guide forest management practices post-closure • Inform the rehabilitation methods and techniques used by future projects within the NJF

4.4.7 Monitoring

Appendix B24 provides an outline of the proposed monitoring methods that could be undertaken for each BI. For each proposed BI the tables provide:

- Data collection methods and design
- Monitoring/ data collection frequency
- Reporting frequency
- Preliminary responses resulting from assessment of data.

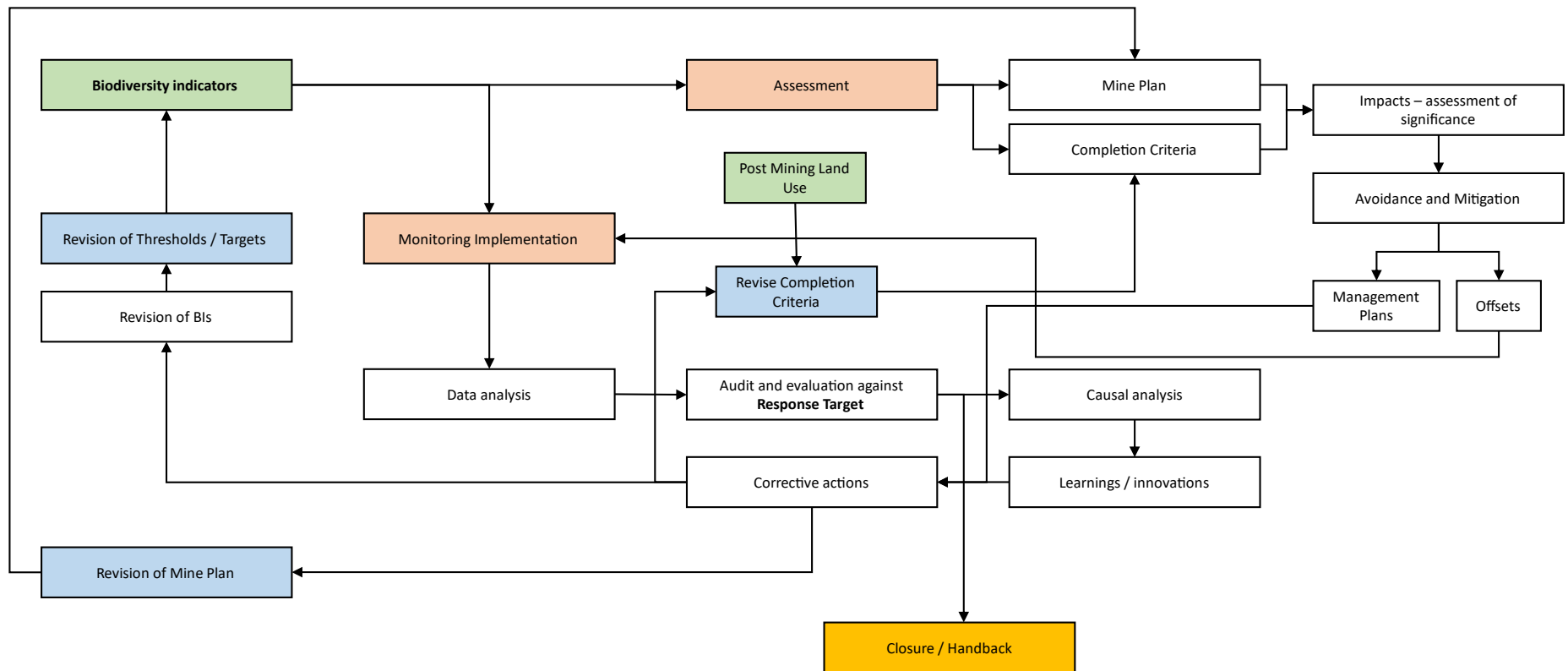


Figure 4-4 BIs and example monitoring framework process