J5 and Bungalbin East Iron Ore Proposal
Public Environmental Review

Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. The environmental impact assessment process is designed to be transparent and accountable, and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, the EPA advises that no decisions have been made to allow this proposal to be implemented.

Mineral Resources Limited proposes to construct and operate the J5 and Bungalbin East proposal about 100 kilometres north of Southern Cross, Western Australia. In accordance with the Environmental Protection Act 1986 (WA), a Public Environmental Review (PER) document has been prepared which describes this proposal and its likely effects on the environment. The PER document is available for a public review period of 8 weeks from 5 September 2016, closing on 31 October 2016.

Comments from government agencies and the public will assist the EPA to prepare an assessment report in which it will make recommendations to government.

Where to get copies of this document

Printed and CD copies of this document may be obtained from Mineral Resources Limited at 1 Sleat Road, Applecross, Perth. Hard copies of the document cost $10 (including postage); CDs will be provided free of charge.

The PER may also be accessed through the proponent's website at: www.mineralresources.com.au

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action – including any alternative approaches. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged with electronic submissions being acknowledged electronically. The proponent will be required to provide adequate responses to points raised in submissions.

In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the Freedom of Information Act 1992, and may be quoted in full or in part in the report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER document or on specific elements. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements in the PER document:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable; and
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that issues raised are clear. A summary of your submission is helpful
- Refer each point to the appropriate section, chapter or recommendation in the PER document
- If you discuss different sections of the PER document, keep them distinct and separate, so there is no confusion as to which section you are considering
- Attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate

Remember to include:

- your name
- address
- date
- whether you want your submission to be confidential.

The closing date for submissions is **31 October 2016**.

The EPA prefers submissions to be made at: https://consultation.epa.wa.gov.au. Alternatively submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bag 10, EAST PERTH WA 6892
- delivered to the Environmental Protection Authority, Level 8, The Atrium, 168 St Georges Terrace, Perth.

If you have any questions on how to make a submission, please ring the Office of the Environmental Protection Authority on 6145 0800.

EXECUTIVE SUMMARY

Mineral Resources Limited (MRL) proposes to develop two new iron ore mines as part of its ongoing mining operations in the Yilgarn area of Western Australia (the “Proposal”).

The Proposal seeks to recover up to 65-115 million tonnes of iron ore having significant economic value to MRL shareholders, employees, local communities and the State of Western Australia. Development and operation of the proposal is scheduled to commence in 2017, with an estimated project life of up to 15 years. The Proposal will contribute to the economic health of Western Australia and will contribute substantially to Government revenue.

MRL’s mining operations in the Yilgarn are forecast to deliver several hundred million dollars in royalties to the Western Australian economy over the next 15 years. The Proposal is the crucial component enabling the continued delivery of these royalties in addition to a range of economic, social and environmental benefits:

- A 70 person construction workforce.
- Continuation of a 425 person permanent workforce dedicated to the Yilgarn operations (J4 mine, rail haulage, Fremantle Ports and MRL Perth).
- Continued investment in exploration and approvals.
- Payments to state-owned ports of tens of millions of dollars per annum.
- Continued investment in Aboriginal heritage work and traineeships.
- Ongoing economic multiplier effects.
- A significant contribution of new scientific knowledge on biodiversity in the Yilgarn.
- Environmental offsets.

The Proposal is situated in the Helena-Aurora Range (HAR), which forms part of the Mt Manning - Helena-Aurora Ranges Conservation Park (MMHARCP), about 100 kilometres (km) north of Southern Cross and 50 km north of Koolyanobbing.

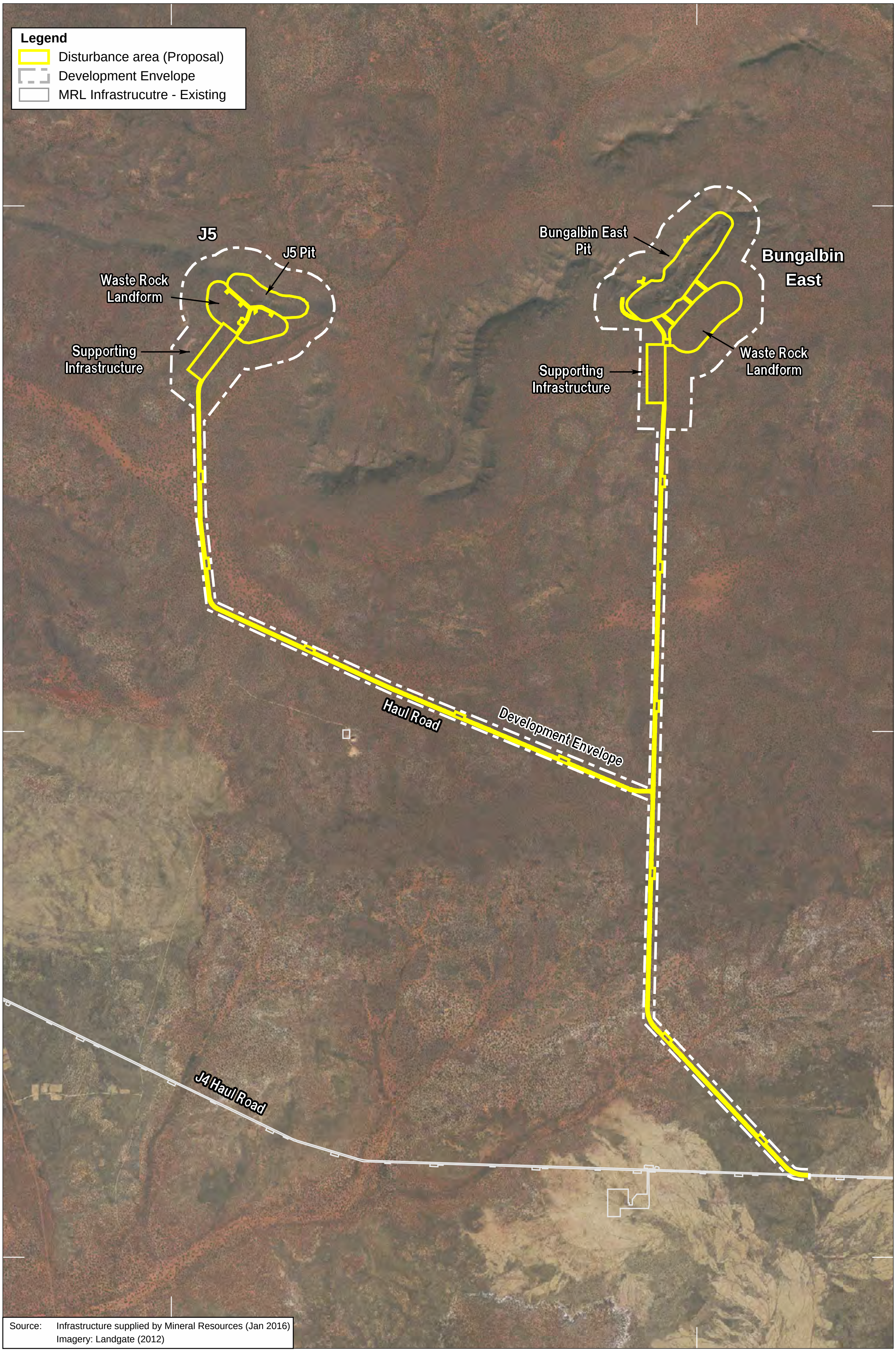
The MMHARCP is managed by the Department of Parks and Wildlife (DPaW) for the purpose of “recreation by members of the public as is consistent with the proper maintenance and restoration of the natural environment, the protection of indigenous flora and fauna and the preservation of any feature of archaeological, historic or scientific interest”.

The MMHARCP is classified as an ‘other than A class’ reserve, which means that activities such as mining can be carried out with the approval of the Minister for Mines in consultation with the Minister responsible for the reserve, in this case the Minister for Environment.

The Proposal comprises open-cut mining of hematite/goethite direct shipping ore (DSO) and road haulage to MRL’s Carina operation, where the ore is processed and loaded onto trains bound for Kwinana/Esperance ports. The total area to be disturbed is 611 ha, comprised of 208 ha for the mine pits, 186 ha for the waste rock landforms, 92 ha for supporting infrastructure and 125 ha for haul roads. The layout of the mines is shown in **Figure E-1**.

The Proposal requires environmental approval from both the Government of Western Australia (WA) and the Australian Government. In this regard it is being formally assessed by the WA Environmental Protection Authority (EPA), which will report to the Commonwealth Minister for the Environment on the environmental factors relevant to the Proposal including the relevant matters of national environmental significance.

This Public Environmental Review (PER) document has been prepared by MRL in accordance with the Environmental Scoping Document (ESD) for the Proposal as well as the generic information requirements listed in Section 10.2.4 of the EPA *Environmental Impact Assessment Administrative Procedures 2012*.



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Date: Jul 2016 | Rev: D | A4

MINERAL RESOURCES

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OVERVIEW OF THE PROPOSAL

Figure:

E-1

The PER identifies the potential impacts of the Proposal on each of the Preliminary Key Environmental Factors identified in the Environmental Scoping Document (ESD), including relevant matters of national environmental significance protected under Commonwealth law. Once management has been applied to avoid, minimise and rehabilitate the impacts, the PER identifies the significance of the residual impacts of the Proposal.

MRL will implement a range of management plans and procedures to minimise and rehabilitate environmental disturbance. Some of these plans and procedures have already been developed and currently apply across all of MRL's operations. Other plans and procedures have been developed specifically for the Proposal. Together, these plans and procedures will comprise the Environmental Management System (EMS) for the Proposal. Should the Proposal receive approval under the EP and EPBC Acts, MRL proposes to seek certification of its EMS to the ISO 14001 international standard.

MRL's environmental practices, including minimising site disturbance, locating infrastructure away from sensitive areas, and backfilling and rehabilitating the southern pit at Bungalbin East, can positively balance conservation with mining.

A summary of the key environmental values, potential impacts, proposed management, residual impacts and predicted outcomes associated with the Proposal is provided for each preliminary key environmental factor in **Table E-1** through to **Table E-8**. MRL acknowledges significant residual impacts to vegetation and flora and has proposed an offsets program to counter these impacts:

- Offsite rehabilitation of historical disturbance and surrender of MRL group exploration tenure within the MMHARCP. The surrender of tenure would be subject to ongoing exclusive conservation tenure arrangements being in place.
- *Tetratheca aphylla* subsp. *aphylla* - Interim Recovery Plan.
- *Lepidosperma bungalbin* - Research Plan and Interim Recovery Plan.

MRL has concluded that there are no significant residual impacts associated with other key environmental factors. MRL also acknowledges the importance of successful rehabilitation to prevent impairment of other land uses that will follow mining. It is MRL's view that the Proposal can be implemented while meeting the objectives of the EPA.

MRL acknowledges that there is a community expectation that mining should be conducted to a high environmental standard and accepts that current and future opportunities for mining companies to recover Australia's resources need to place significant emphasis on environmental protection. To this end, MRL is developing new initiatives to help position itself as an industry leader in environmental management. For example:

- MRL was awarded the 2015 AMEC Environment Award in recognition of its research partnership with Curtin University investigating biodiversity modelling of Yilgarn BIF ranges.
- MRL is part of a consortium of mining companies and academic institutions implementing a $7 million Australian Research Council grant for an integrated research training program for mine rehabilitation - this program is focussed on improved mining rehabilitation outcomes and better conservation management of significant biodiversity assets where effects from mining cannot be avoided.

MRL has compiled this PER to inform the EPA's assessment and to provide the opportunity for discussion and ideas about the Proposal. MRL is open to suggestions for improvement of the management measures outlined.

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TABLE E-1: FLORA AND VEGETATION - SUMMARY OF IMPACTS, MITIGATION AND ENVIRONMENTAL OUTCOMES

EPA Objectives	Key environmental values	Potential impacts	Management	Residual impact	Environmental outcome
Flora and vegetation: To maintain representation, diversity, viability and ecological function at the species, population and community levels. Offsets: To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.	The flora and vegetation of the Proposal area is well understood through existing survey data and the detailed surveys undertaken on behalf of MRL for this Proposal. The key values in and around the Proposal area are: • The Helena and Aurora Range vegetation complexes (banded ironstone formation) Priority Ecological Community (HAR PEC). • Forty-five vegetation units mapped with the study area. A suite of 13 vegetation units aligns approximately with the PEC as mapped by DPaW and has been used as a HAR PEC analogue in the assessment. • Two threatened taxa - *Tetratheca aphylla* subsp. *aphylla and Leucopogon spectabilis.* Both are listed under the *Wildlife Conservation Act 1950* (WA) and the Commonwealth's *Environment Protection and Biodiversity Act 1999*. • Seventeen taxa listed as Priority Flora by DPaW. • Weed numbers and distribution within the study area are low.	The potential impacts associated with the Proposal are: • Land clearing of up to 611 ha of vegetation and flora. • Reduction in the extent of vegetation of conservation significance, in particular the HAR PEC. • Reduction in the numbers of threatened flora, including impacts on two threatened taxa. Includes some potential loss of genetic diversity within *Tetratheca aphylla* subsp. *aphylla*. • Reduction in the numbers of twelve taxa listed as Priority Flora. • Potential indirect impacts include foliar dust deposition and loss of condition; introduction and/or spread of weeds; fragmentation and adverse changes to microhabitats; impacts due to alteration of surface water flows; changes to fire regime, and grazing by feral animals.	A footprint of 611 ha has been proposed. Options for avoidance of impacts associated with land clearing within this footprint are limited as the proposed location of the open pits cannot be changed. It may be possible to avoid some conservation significant vegetation and taxa occurring within the footprint for the open pits. The land clearing process will be managed as per existing MRL procedures relating to Site Disturbance Permits (MRL-EN-PRO-0005) and Land Clearing (MRL-EN-PRO-0004). These procedures require that the planning and implementation of land clearing are undertaken in a controlled manner. Development and implementation of more detailed work instructions relating to particular aspects of the environment will be required. Group-wide procedures for Dust Management (MRL-EN-PRO-0012), Weed Hygiene and Control (MRL-EN-PRO-0007), Incident Reporting (MRL-OHM-PRO-0007) and Land Rehabilitation (MRL-EN-PRO-0009) will apply. Additional processes for re-establishment of local native vegetation and for control of dust associated with blasting will be developed and implemented. The rehabilitation processes will include the propagation of some taxa occurring within the Proposal footprint which some level of genetic diversity. A monitoring program for indirect impacts, including trigger and threshold criteria, is outlined in a draft Conservation Significant Species and Communities Management Plan (CSSCMP). MRL will not conduct any burning of vegetation and will have in place procedures for activities that carry some risk of inadvertent fire. The Proposal is not expected to influence the very low local populations of grazing animals, surface water flows which could affect vegetation or fragmentation and adverse changes to microhabitats at a significant level.	The significant residual impacts of the Proposal on flora and vegetation are: • Land clearing of up to 611 ha of native vegetation, including removal and potential indirect impacts to up to 385.4 ha (6.9 %) of the HAR PEC. • Removal of and indirect impacts to individual vegetation units contained within the PSRN supergroup and which host taxa of conservation significance. • Removal of and indirect impacts to approximately 26,000 individuals (29.4 %) of the threatened *Tetratheca aphylla* subsp. *aphylla*. • Removal of and indirect impacts to approximately 18,000 individuals (39.7 %) of *Lepidosperma bungalbin* (P1). • Other residual impacts include: • Removal of and indirect impacts to approximately 9,000 individuals (12.3 %) of *Acacia adinophylla*. (P1). • Removal of small numbers of individuals (~1 % or less) of the threatened *Leucopogon spectabilis* and *Acacia shapellae* (P1). • Removal of and indirect impacts to a number of individuals of P3 and P4 taxa, the most substantial impact of 18.8% which is on *Banksia arborea* (P4). • Where residual impacts are significant, the following offsets are offered: • Funding for the preparation and implementation of an Interim Recovery Plan for Tetratheca aphylla subsp. aphylla. • Funding for the preparation and implementation of a Research Plan and an Interim Recovery Plan for Lepidosperma bungalbin. • In consultation with DPaW, offsite rehabilitation of historical disturbance and surrender of MRL group exploration tenure within the MMHARCP. The surrender of tenure would be subject to ongoing exclusive conservation tenure arrangements being in place.	In considering the EPA's objective for flora and vegetation, representation and diversity will be unaltered as there are no taxa, vegetation units or supergroups that will be removed in their entirety. However, following some investigations into intra-species diversity, some measures are proposed to prevent the loss of some genetic differentiation in *Tetratheca aphylla* subsp. *aphylla*. Viability of key elements of the flora and vegetation is a primary consideration given that many are restricted in their range and occurrence. While the Proposal involves removal of individuals of Threatened and Priority taxa, and of a small proportion of the HAR PEC, it also offers the opportunity to gain a better understanding of their ecology through research and monitoring. Although the Proposal will permanently remove a portion of habitat, the viability of taxa and vegetation within adjacent areas can be maintained through careful implementation of the Proposal and application of conditions and management measures to protect or enhance remaining populations. Ecological function can be maintained within intact vegetation which will remain unaltered. Rehabilitation will seek to re-establish flora and vegetation of conservation significance. Through an offsets program, the Proposal offers an opportunity to achieve on-ground improvements elsewhere within the MMHARCP as well as to gain a much better understating of particular taxa of conservation significance. The EPA's objective for flora and vegetation can be met.

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TABLE E-2: LANDFORMS - SUMMARY OF IMPACTS, MITIGATION AND ENVIRONMENTAL OUTCOMES

EPA Objective	Key environmental values	Potential impacts	Management	Residual impact	Environmental outcome
To maintain the variety, integrity ecological functions and environmental values of landforms.	Environmental values of the landform include: • nature conservation • cultural • recreation and tourism • education • monitoring and research. The landform supports geographically restricted plant communities having high levels of endemism i.e. supporting plants that occur nowhere else. Erosion has been the primary mechanism in landform development, with BIF geology being resistant to erosion and outcropping as isolated ranges, elongated ridges and prominent hills throughout the Yilgarn. These ranges support plant communities having strong correlation to geological substrates and soil-topographic gradients.	The potential impacts of the Proposal on landforms are: • loss of integrity of landforms arising from temporary or permanent structural alteration of landforms • temporary or permanent reduction and/or degradation of ecological function associated with the landforms • temporary or permanent degradation or loss of environmental values associated with the landforms.	Avoidance of impacts on the landforms (i.e. the HAR) is not possible as the location of the mine pits cannot be changed. The pit voids at J5 and Bungalbin East will be a permanent feature of the landscape. This will be partially mitigated at Bungalbin East, where mining will commence at the south western end of the deposit which will then allow partial backfilling with mine waste from the north eastern end of the mine. Waste rock landforms (WRLs) will be contoured and rehabilitated using leading practice methods informed by specialist mine closure and rehabilitation advice and in accordance with approval conditions. Rehabilitation will be undertaken progressively over the life of the mine. Over time the modified landform will provide habitat for flora and fauna species, thereby offsetting some of the impact from the mine pit.	The residual impacts of the Proposal on landforms are: • The mine pits, abandonment bunds and associated development will extend over a total area of 210 ha. • This represents an increase to disturbance of the landform to around 6.5% (including existing disturbance). • Open pit voids will remain at both J5 and Bungalbin East; however backfilling and rehabilitation of the southern pit at Bungalbin East will reduce the extent of this impact. • New landforms (WRLs) will be developed over a total area of185 ha adjacent to the existing landform. • Pit voids and new landforms will result in localised alterations to landform contours and surface drainage patterns. • Residual impacts to landforms are not significant as ecological function can be maintained elsewhere, and returned to the majority of the disturbed area following rehabilitation and mine closure.	The proposal will result in localised permanent change to relatively small proportion of the total length of BIF ranges within the MMHARCP (2.8%). The proposal will partially modify about 1.4 km of BIF at J5 and 2.4 km of BIF at Bungalbin East. There will be minimal impact to the northern-most flanks of the landforms at J5 and Bungalbin East, as these areas are outside the disturbance area. Over 97% of the BIF within the MMHARCP will remain intact i.e. unaffected by mining. The integrity, ecological functions and environmental values of these undisturbed areas will remain intact.

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TABLE E-3: SUBTERRANEAN FAUNA – SUMMARY OF IMPACTS, MANAGEMENT AND ENVIRONMENTAL OUTCOMES

EPA Objective	Key environmental values	Potential impacts	Management	Residual impact	Environmental outcome
To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	Field surveys were conducted for both troglofauna and a desktop survey for stygofauna. The desktop survey concluded that the fractured rock aquifers at J5 and Bungalbin East will not contain a significant assemblage of stygofauna as previous surveys of similar aquifers in the region have not produced any evidence of stygofauna occurrence. Drill holes at both J5 and Bungalbin East yielded troglofauna. Overall, the total sampling effort at J5, Bungalbin Central and Bungalbin East has yielded 57 troglofauna specimens of nine orders and 16 species. The field survey in 2015 collected 12 species from J5 and four species from Bungalbin East. There are some shared species between these deposits and at least four species potentially occur at other deposits in the Jackson Range or elsewhere. Nine troglofauna species are known only from Bungalbin East (two species) or J5 (seven species).	The Proposal will impact troglofauna directly as well as potential troglofauna habitat The extent of impact on habitat is small taking into account the fact that most forms of weathered BIF are prospective for troglofauna in the Yilgarn and that inter-connected BIF is present within the HAR and surrounding BIF ranges. For the same reason, the troglofauna taxa recorded within the disturbance area as singletons (i.e. only known from one record) are expected to occur elsewhere as there are no clear barriers to dispersal between the Helena-Aurora Range and the Mt Jackson Range, despite some minor fault lines and alluvial plains that bisect the J5 and Bungalbin East deposits. The potential impact on stygofauna, if present, as a result of groundwater abstraction will be minor.	No specific management of subterranean fauna is proposed.	The residual impact comprises the removal of all troglofauna individuals and their habitat within the pit areas. The mine pit areas are small compared to the known ranges of highly restricted troglofauna species elsewhere in Western Australia. The goethite mineralisation at J5 and Bungalbin East is restricted in distribution; however siliceous BIF geology extends more or less continuously for many kilometres. Much of this geological unit is weathered and therefore provides troglofauna habitat. Given the extent of available habitat, the Proposal is unlikely to have a significant impact on troglofauna conservation values. The potential impact on stygofauna is not significant.	The EPA's objective for subterranean fauna can be met.

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TABLE E-4: TERRESTRIAL FAUNA – SUMMARY OF IMPACTS, MANAGEMENT AND ENVIRONMENTAL OUTCOMES

EPA Objective	Key environmental values	Potential impacts	Management	Residual impact	Environmental outcome
To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	Field surveys were conducted for vertebrate fauna and short-range endemic (SRE) invertebrate fauna. Six major vertebrate fauna habitat types were identified within the study area. The most extensive fauna habitat type is 'mixed eucalypt woodland' (63%). Three habitat types – 'rocky ridge', 'drainage line' and 'seasonal swamp' – together occupy less than 4 % of the study area. A total of 17 native and three introduced species of mammals, 87 species of bird, 48 species of reptile and two species of amphibians were recorded in surveys. Fauna database searches, literature review and field surveys were completed during 2012-13. Eleven species of conservation significance were either recorded in surveys and/or had a medium to high likelihood of occurrence within the study area. A further 29 species had a low likelihood of occurrence and/or were not recorded Since 2013 there have been numerous revisions to fauna listings under WA legislation, such that the 11 conservation significant species of interest are considered under different listing categories or in some cases are not considered further as they have been de-listed. Four of the six vertebrate species of conservation significance having a medium to high likelihood of occurrence were recorded during field surveys, all of which were birds: • Rainbow Bee-eater (Migratory; Schedule 3). • Peregrine Falcon (Schedule 4). • Malleefowl (Vulnerable, Schedule 1). • Fork-tailed Swift (Migratory, Schedule 3). A further two vertebrate species also having a medium to high likelihood of occurrence were not recorded during field surveys. These were the Chuditch (Western Quoll) and Woma. Although suitable habitat for each of these species is broadly present in the study area in the form of mixed eucalypt woodland, there are only a few previous records of each species within 100 km of the study area. With regard to short-range endemic (SRE) invertebrate fauna, surveys recorded 449 specimens belonging to 80 species across seven SRE invertebrate groups. One listed invertebrate species (*Aganippe castellum* - Tree-Stem Trapdoor Spider, Priority 4), 51 potential SRE species and two confirmed SRE species (the spider *Idiosoma* sp. B02 and the millipede *Antichiropus westi*) were recorded. All listed and confirmed SRE species occur within and beyond the disturbance area. Of the 51 potential SRE species, six species have only been found inside the disturbance area, comprising four mygalomorph spiders, one pseudoscorpion and one snail.	Potential impacts associated with the Proposal are: • Loss of individuals and their habitat due to land clearing. • The only conservation-significant species known to occur within areas proposed for clearing is the Tree-stem Trapdoor Spider (*Aganippe castellum*). This species is a DPaW Priority 4 species and is fairly widespread. It is also known from the Koolyanobbing and Mt Jackson Ranges. • An undescribed species of spider (Idiosoma sp. B02) inhabits woodland areas and its distribution is limited to the Koolyanobbing and Helena-Aurora ranges. It currently belongs to the *Idiosoma nigrum* complex but is known to be a different species from *I. nigrum*. It was recorded both within and outside the disturbance area. • Habitat degradation though dust, noise, vibration and light emissions. • Changes to the fire regime. • Attraction of feral animals by sources of water and food waste. • Vehicle strike.	The land clearing process will be managed as per existing MRL procedures relating to Site Disturbance Permits (MRL-EN-PRO-0005) and Land Clearing (MRL-EN-PRO-0004). Group-wide procedures for Dust Management (MRL-EN-PRO-0012), Weed Hygiene and Control (MRL-EN-PRO-0007), Incident Reporting (MRL-OHM-PRO-0007), Fauna Management (MRL-EN-PRO-0001) and Land Rehabilitation (MRL-EN-PRO-0009) will apply. An additional process for control of dust associated with blasting will be developed. There will be no burning of vegetation or any other materials. MRL-EN-PRO-0001 includes provision for: • Induction and training for all site personnel on fauna occurrence, obligations and management, including the need for qualified fauna handlers. • Fencing of all dams and fauna egress matting for dams lined with High-Density Polyethylene (HDPE) that would otherwise prevent animals from escaping the water. • Prohibition on handling animals unless qualified and on feeding animals. • Storage of food and disposal of organic waste such that it does not create sources of food. • Adherence to all speed limits, removal of any dead fauna (road kill) and prohibition on driving outside the disturbance area without an approved Site Disturbance Permit. • Removal of all dams and associated water infrastructure such that there will be no permanent water sources once mining is complete. • Rehabilitation will achieve a level of habitat restoration.	Loss of habitat for fauna generally beyond that which can be restored through rehabilitation.	The EPA's objective for terrestrial fauna can be met.

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TABLE E-5: HYDROLOGICAL PROCESSES AND INLAND WATERS ENVIRONMENTAL QUALITY – SUMMARY OF IMPACTS, MANAGEMENT AND ENVIRONMENTAL OUTCOMES

EPA Objectives	Key environmental values	Potential impacts	Management	Residual impact	Environmental outcome
To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected. To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.	The Proposal is located at the eastern extent of the Swan-Avon River Catchment (Yilgarn Branch) within the South-West Drainage Division of Western Australia. Regional-scale catchments drain towards a series of large, intermittent salt lakes that are generally dry through most years and fill only following periods of substantial rainfall. There are no permanent or semi-permanent surface water bodies within 60 km of the Proposal. Surface run-off is highly ephemeral, with few defined channels forming in the landscape. The mine and infrastructure areas are situated on locally elevated areas within the upper reaches of a regional catchment that drains towards Lake Hamersley, some 60 km away. At J5 there is a regional-scale catchment that directs water to the east of the disturbance area. Regional groundwater levels are inferred to be 410 m AHD; however localised groundwater mounding is expected to occur beneath BIF ranges. Estimated groundwater levels at J5 and Bungalbin East are 420 m Australian Height Datum (AHD) and 450 mAHD, respectively. Groundwater quality is expected to be brackish at higher elevation and progressively more saline at depth.	The potential impacts of the Proposal on hydrological process and water quality are: • Alteration of natural surface water flows and contamination of surface water as a result of placement, design and operation of the mine and associated infrastructure. • Alteration of surface water flows may result in changes to natural erosion and deposition patterns that could increase the turbidity of surface water. • Degradation and/or loss of vegetation and associated sterilisation of soil arising from the use of saline water for operational purposes such as dust suppression. Pit dewatering is not proposed as the pit mining operations will be above the water table. Groundwater resources are deep and support neither stygofauna nor groundwater-dependent ecosystems.	Surface water will be managed through the implementation of a Surface Water Management Plan (**Appendix 9-C**) and an existing MRL procedure relating to Surface Water Management (MRL-EN-PRO-0003). The Surface Water Management Plan identifies the following management actions: • Ensure diversions/drains maintain continuity of flow through the catchment by returning diverted flows to natural flow pathway. • Remove drains and re-establish natural drainage at site closure. • Design and construct haul roads with low-pass floodways and other appropriate cross-road drainage and turnouts. • Bunding around chemical and fuel storage areas, and drainage control around infrastructure and constructed landforms (waste rock landforms, topsoil stockpiles). • Groundwater will be managed using an existing MRL procedure relating to Groundwater Management (MRL-EN-PRO-0013) and Dust Management (MRL-EN-PRO-0012)and will include: o Fitting of automated high level detection shut-off devices on all saline water pipelines discharging to turkey nest dams o Maintenance of 300mm freeboard within turkey nest dams o Installation of secondary containment around; o Turkey nest dams will be lined with HDPE membrane to prevent seepage; o Controls on water cart operations.	Residual impacts include: Removal of a small portion of the upper reaches of a regional catchment as a result of the excavation of three mine pits. Alteration of a small portion of the upper reaches of a regional catchment as a result of the construction of three waste rock landforms. Minor abstraction of groundwater adjacent to the mine pits.	The EPA's objectives for hydrological processes and inland waters environmental quality can be met.

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TABLE E-6: AMENITY – SUMMARY OF IMPACTS, MANAGEMENT AND ENVIRONMENTAL OUTCOMES

EPA Objective	Key environmental values	Potential impacts	Management	Residual impact	Environmental outcome
To ensure that impacts to amenity are reduced as low as reasonably practicable.	The MMHARCP is a relatively undisturbed natural environment that offers visitors the opportunity to experience a remote, outback experience within a varied landscape that contains diverse native flora and fauna The scenic qualities of the MMHARCP emanate primarily from its distinctive rock formations, rugged ridgelines and contrasting vegetation patterns. The HAR's high level of visibility and the complexity of the landform and its habitats means that it contributes significantly to the "sense of place" associated with the MMHARCP. In addition, the MMHARCP: • is a relatively quiet environment with background noise consisting of wind, rain and bird calls • has low levels of dust, consistent with its predominantly natural setting • has no permanent sources of light.	The potential impacts of the Proposal on amenity include impacts on: amenity values (including visual landscape, scenic and visual aesthetic values, and recreational tourism) in a conservation park prominent and important landform features relative to this landscape character type social values (e.g. aesthetics or active use) of the landform(s) it supports (temporarily or permanently) including access, noise and vibration, dust emissions and light pollution.	The potential impacts to amenity will be managed through implementation of MRL's Environmental Management System for the Proposal, which includes an Amenity Management Plan (AMP) (**Appendix 10-E**). The AMP identifies management and mitigation measures for the Proposal, including closure and rehabilitation outcomes, to ensure that residual impacts on amenity are not greater than predicted. Management of visual amenity, visitor use and public access, and emissions such as dust, noise and light will be in accordance with the EPA project-specific objective to ensure that impacts to amenity are as low as reasonably practicable. The AMP sets out the management approach for amenity, the key elements of which include: • Minimise loss of public access to the MMHARCP by closing only those roads needed for operational and safety purposes and not excluding access to campsites within the Conservation Park. • Siting project infrastructure to ensure that these are obscured from public view as much as possible by, for example, placing facilities within woodlands on adjacent plains rather than on foot slopes or ridges of the HAR. • Minimise noise and vibration emissions during construction, operations and closure and provide appropriate signage to visitors and campers in the MMHARCP regarding mining and blasting noise and vibration occurring in the vicinity. • Minimise dust emissions during construction, operations and closure through the use of dust suppression techniques on haul roads, active mining areas, waste rock landforms and other cleared areas.	There will be residual impacts on visitor use and access as well as the visual landscape, although these are not considered to be significant for the following reasons: There are no permanent sensitive receptors or permanent residences within the MMHARCP, and visitation is considered to be low; • A number of tracks currently provide access to the MMHARCP and it is expected that most of these will remain open to public access during the life of the Proposal. Limited local track closures will occur to ensure public safety; • There are other areas of the MMHARCP (including areas at lower elevations) that do not have a clear line of sight to the Proposal i.e. the Proposal is not visible from these locations. Visitors can still experience the remote and natural environment of the MMHARCP at the same time that mining is occurring; • The disturbance footprint of the Proposal within the MMHARCP is considered small compared to the area of the MMHARCP that remains undisturbed, and the Proposal is potentially located within an area of the MMHARCP which has the same landform values also represented elsewhere across the MMHARCP. • The mine pits will remain as open voids, however the southern pit at Bungalbin East, and the WRLs will be constructed in a manner that ensures these new landforms will be safe, stable, non-polluting and able to sustain native vegetation in the long term (**Appendix 10-B**). The Rehabilitation and Mine Closure Plan (**Appendix 12-D**) developed for the Proposal outlines the rehabilitation activities and the monitoring and maintenance framework that will be implemented to ensure the success of the mine rehabilitation and closure programs. This framework includes monitoring for physical stability and erosion of rehabilitated areas and allows for repair works where required and various monitoring methods to be implemented, with monitoring continuing until the completion criteria agreed for each of the closure domains have been achieved.	The level of impact to amenity will vary during the different phases of the Proposal, i.e. construction, operations and closure, with some impacts being more temporary in nature. For example, noise impacts from blasting will occur over only a few seconds per day, but changes to some aspects of the visual landscape from development of the mine pits and WRLs will be permanent. The Proposal has been designed to minimise impacts on amenity and has appropriate management measures in place to actively monitor and manage residual impacts on amenity as a result of implementation of the Proposal. The Proposal can therefore meet the EPA objective to ensure that impacts to amenity are reduced to as low as reasonably practicable.

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TABLE E-7: HERITAGE – SUMMARY OF IMPACTS, MANAGEMENT AND ENVIRONMENTAL OUTCOMES

EPA Objective	Key environmental values	Potential impacts	Management	Residual impact	Environmental outcome
To ensure that historical and cultural associations, and natural heritage, are not adversely affected.	At the time of European colonisation the Helena-Aurora Range and the surrounding country were occupied by the Kaparn and Kelamaia Kabu(d)n Peoples. Both these groups lived a hunter-gatherer lifestyle. Archaeological evidence of the use of the country by Aboriginal people is manifested in historical artefacts such as stone artefacts, scar trees, water trees, rockholes, and ceremonial sites. Other connections include the continuing use of bush resources for food and medicines and the transmission of cultural knowledge. The WA Department of Aboriginal Affairs (DAA) formally recognises Aboriginal heritage by classifying a locations with heritage value as either a 'Registered Site' (RS) or an 'Other Heritage Place' (OHP). There are no registered Heritage Sites within the MMHARCP. However there are 14 OHPs of which seven occur in proximity to the Proposal. Surveys completed by MRL have also identified a further six sites not yet recorded in DAA databases and a corrected location for an OHP.	The potential impacts of the Proposal on Aboriginal heritage relate to disturbance of Aboriginal heritage sites and/or cultural associations – this will include five of the seven OHPs occurring in proximity to the Proposal: • J5 Rockhole 1 (29178) • J5 Rockhole 2 (29179) • KY28 (20342) • Aurora Range Women's Place (18726) • Helena Cave (18732) • Site 252 may also be affected. With these exceptions, alteration of Aboriginal heritage and cultural values associated with the Conservation Park will not be significant. Access to the area by the Kaparn and Kelamaia-Kabu(d)n will be largely unrestricted.	MRL will strictly observe the relevant provisions of the *Aboriginal Heritage Act 1972*, the *Environmental Protection Act 1986* and the aspirations of the relevant Aboriginal groups in respect of the OHPs to be impacted, to the greatest extent possible. The aim of mitigation and management procedures is to strengthen and extend the heritage link with country in general, even in cases where an individual "site" will be lost. Mitigation of impacts includes avoidance of sites where this is possible and documentation of those that cannot be avoided. Inadvertent impacts will be avoided by standard procedures related to ground disturbance, demarcation and signage, induction and cultural awareness training.	The Proposal will have a residual impact on Aboriginal heritage to the extent that five OHPs and potentially one other site will be disturbed and ultimately lost. By involving Aboriginal groups in heritage surveys and in the ongoing management of their heritage and culture in the Proposal area, the cultural link with the land in the MMHARCP will likely, in fact, be strengthened rather than adversely affected.	The EPA objective for heritage can be met.

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TABLE E-8: REHABILITATION AND DECOMMISSIONING (INTEGRATING FACTOR) – SUMMARY OF IMPACTS, MANAGEMENT AND ENVIRONMENTAL OUTCOMES

EPA Objective	Key environmental values	Potential impacts	Management	Residual impact	Environmental outcome
To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.	Implementation of the Proposal will result in significant changes to the local landscape. Three waste rock landforms and three open pit voids will be created. The Proposal cannot be implemented without these impacts. However, given the location of the Proposal within the Mt Manning – Helena-Aurora Ranges Conservation Park (MMHARCP), the standard of rehabilitation and decommissioning works completed will have an impact on the future value of the area for conservation and recreation.	The standard of rehabilitation and decommissioning works completed will have an impact on the future value of the area for conservation and recreation. Potential impacts associated with the Proposal are: • Permanent alteration of the landform(s) and associated natural hydrology, flora and fauna. • Acid rock drainage (ARD) and/or metalliferous drainage (MD). • Unsuccessful rehabilitation of flora and vegetation in cleared/developed areas. • Impact on soils from compaction and erosion. • Impediment of rehabilitation success due to the spread of weeds. • Other threatening processes (i.e. trampling by feral animals, increased risk of fire) impeding rehabilitation process.	Soil and waste rock materials have been characterised and a draft Rehabilitation and Mine Closure Plan has been prepared. The Plan identifies four domains within the Proposal and outlines how each will be rehabilitated and closed. Topsoils and subsoil management will be key considerations and revegetation with local native species is the aim. Group-wide procedures for Dust Management (MRL-EN-PRO-0012), Weed Hygiene and Control (MRL-EN-PRO-0007), Land Clearing (MRL-EN-PRO-0004) and Land Rehabilitation (MRL-EN-PRO-0009) will apply but will be supplemented by site-specific plans and procedures informed by the environmental assessment process. Waste characterisation studies concluded the risk of intersecting and disturbing materials which may generate ARD or MD is considered low and any residual sulfides present can be effectively managed through either encapsulation or dilution within non-acid forming waste.	The residual impacts associated with rehabilitation and decommissioning will depend on how well the mine rehabilitation program can be planned and implemented. Successful rehabilitation outcomes are being achieved at mining projects associated with banded iron formations. Where particular attention is paid to topsoil and subsoil management, and special measures adopted for return or translocation of target taxa, successful outcomes appear within reach. A post-closure monitoring and management program of at least five years is proposed.	The EPA's objective for rehabilitation and decommissioning can be met.

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1. INTRODUCTION

Mineral Resources Limited (MRL) proposes to develop two iron ore deposits, namely Jackson 5 (J5) and Bungalbin East, situated in the Helena-Aurora Range (HAR) about 100 kilometres (km) north of Southern Cross in Western Australia (WA) (the Proposal) (**Figure 1-1**).

The Proposal comprises the construction, operation and closure of two mines and associated haul roads, waste rock landforms (WRL) and supporting mine infrastructure such as site offices, water storage, pipelines, fuel storage, power generation and telecommunications.

The HAR is one of numerous Banded Iron Formation (BIF) ranges that occur across WA's Mid-West and Avon-Wheatbelt/Goldfields regions. The Proposal's location within the Mt Manning – Helena-Aurora Ranges Conservation Park (MMHARCP) represents a focal point for the debate on mining and conservation of BIF ranges.

This document is a Public Environmental Review (PER) of the Proposal as required under the WA *Environmental Protection Act 1986* (EP Act) and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The PER provides an opportunity for anyone to inform themselves about the Proposal and its environmental effects and to provide comments for consideration by the Environmental Protection Authority (EPA) when assessing the Proposal and making its recommendations to the Western Australian and Australian governments on whether the Proposal should proceed.

1.1 Ownership

The proponent for the Proposal is MRL and enquiries can be directed in writing to the contact details provided below:

Mineral Resources Limited
Locked Bag 3, Canning Bridge
Applecross WA 6153
reception@mineralresources.com.au

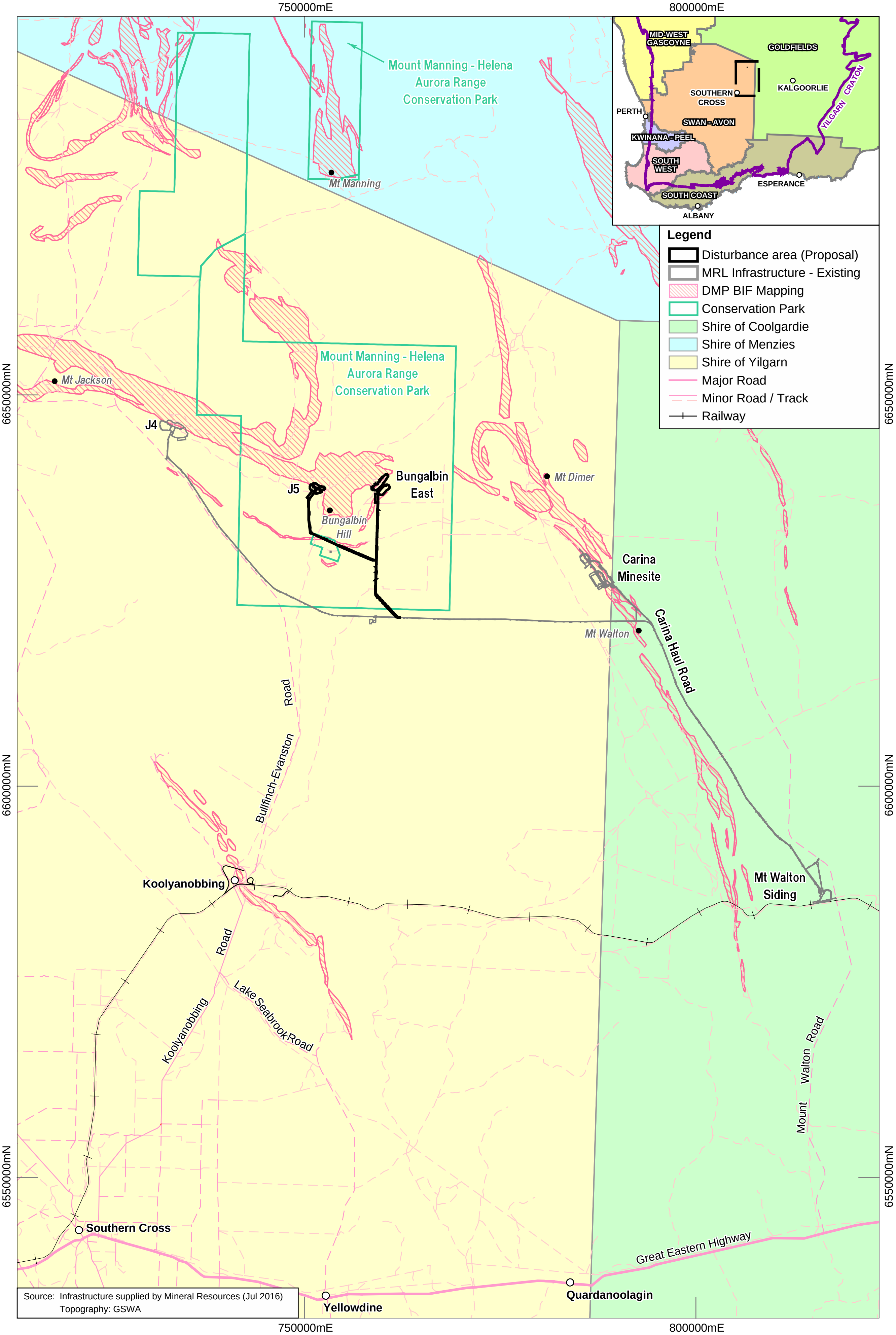
MRL is a developing iron ore producer with a portfolio of assets across BIF ranges in the Yilgarn area near Southern Cross. These assets include operational mines at Carina and J4 as well as confirmed deposits at Chameleon, Carina Extended, J5 and Bungalbin East.

MRL's environmental operations are guided by the company's Environment and Community Policy, the goal of which is to cause no environmental harm beyond that necessary to conduct its business and for which statutory approval has been obtained (**Appendix 1-A**).

1.2 Land Tenure

The Mt Manning area comprises a variety of land tenure including vacant crown land, reserves and proposed reserves as well as pastoral leases and granted/pending mining leases, mineral exploration leases general purpose leases and miscellaneous licences (**Figure 1-2**).

Details of relevant granted and pending mining tenure for the Proposal are provided in **Table 1-1** and displayed in **Figure 1-3**.



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Scale

MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C01_F01_01

Date: Jul 2016 | Rev: C | A4

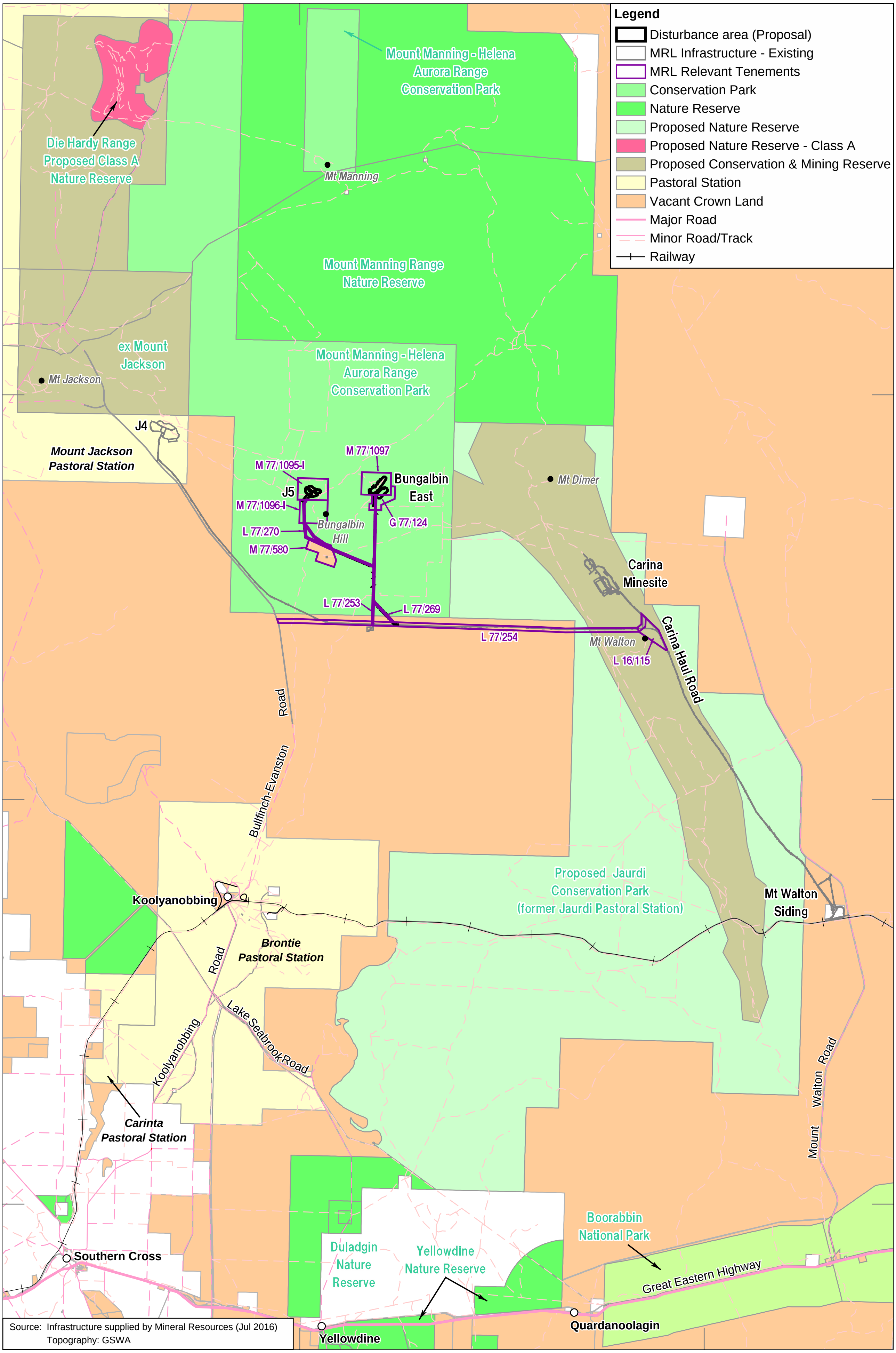
Author: Mineral Resources

Drawn: CAD Resources ~ www.cadresources.com.au

Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

LOCATION OF THE PROPOSAL

Figure: **1-1**



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MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C03_F03_01

Date: Jul 2016 | Rev: C | A4

Author: Mineral Resources

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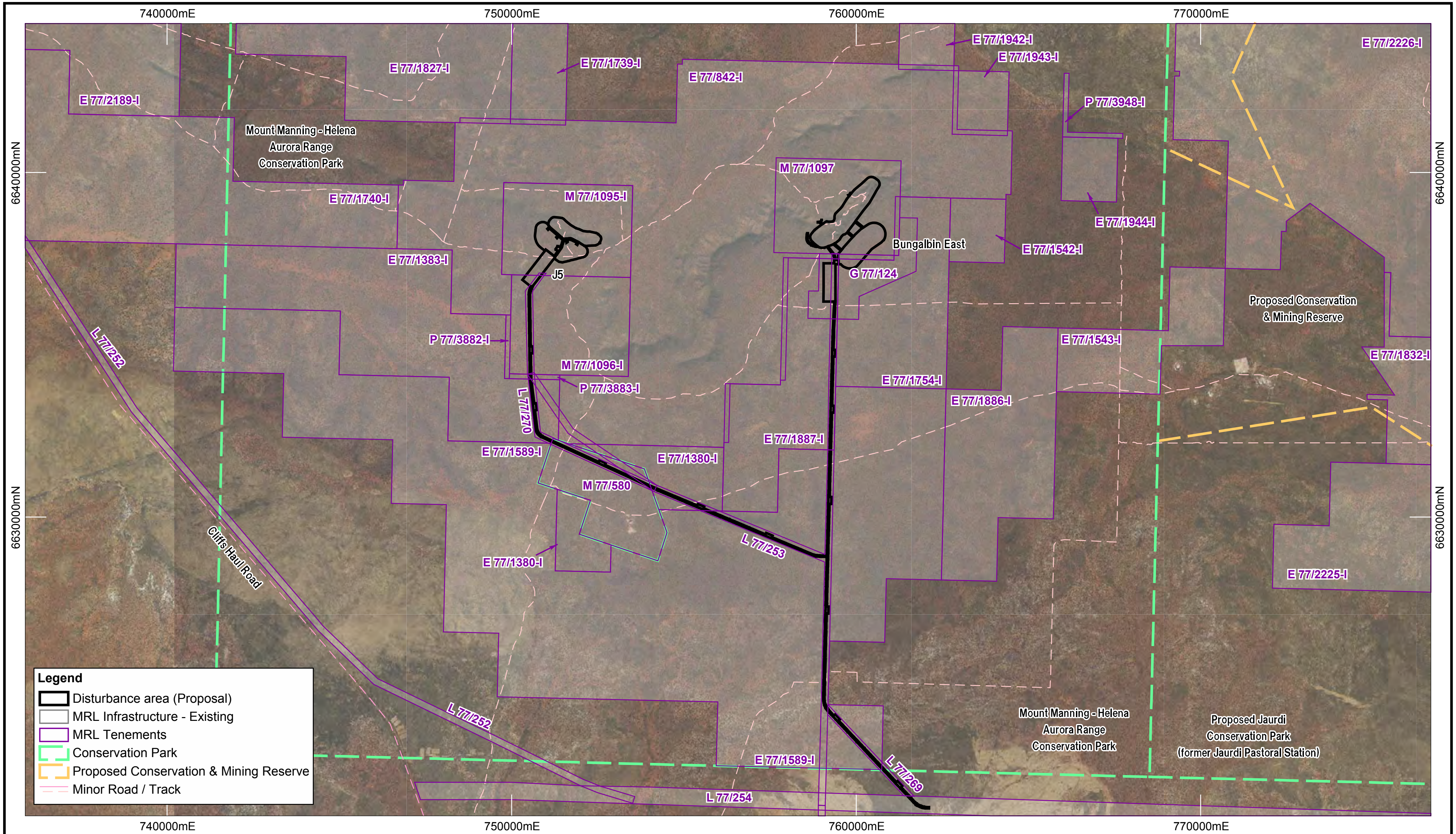
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

LAND TENURE OVERVIEW

Figure: 1-2



Source: Infrastructure supplied by Mineral Resources (Apr 2016)
Imagery: Landgate (2012)
Tenure: DMP / DPaW

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0 1.5 3km

Scale 1:150,000
MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C03_F03_02

Date: Jul 2016 | Rev: C | A4

Author: Mineral Resources
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

DETAILED LAND TENURE

Figure:

1-3

TABLE 1-1: TENEMENT OWNERSHIP

Lease Category	Tenement	Ownership/Applicant	Grant Date	Area (ha)
Mining Lease	77/1095-I	Polaris Metals Pty Ltd	9 May 2011	997.95
Mining Lease	77/1096-I	Polaris Metals Pty Ltd	9 May 2011	992.35
Mining Lease	77/1097	Polaris Metals Pty Ltd	Pending	998
Mining Lease	77/580	Polaris Metals Pty Ltd	15 June 1993	702.45
Miscellaneous Licence	77/253	Polaris Metals Pty Ltd	Pending	581
Miscellaneous Licence	77/270	Polaris Metals Pty Ltd	Pending	108.25
Miscellaneous Licence	77/269	Polaris Metals Pty Ltd	Pending	70.42
General Purpose Lease	77/124	Polaris Metals Pty Ltd	Pending	437.70

This mining tenure coexists and is surrounded by reserves or proposed reserves:

- Mt Manning – Helena-Aurora Ranges Conservation Park (MMHARCP) (other than class A) (48470).
- Mt Manning Range Nature Reserve (other than class A) (36208).
- Proposed Jaurdi Conservation Park, comprised of a portion of the former Jaurdi pastoral station purchased by the Department of Conservation and Land Management (CALM) in July 1989.
- Proposed Mt Elvire Conservation Park, comprised of a portion of the former Mt Elvire pastoral station purchased by CALM in June 1991.
- Proposed nature reserve at the Die Hardy Range (class A), comprised of a portion of the Diemals pastoral lease as defined through the 2015 pastoral lease excision process.
- Proposed reserves for conservation and mining comprised of portions of the Mt Jackson and Diemals pastoral leases and former Jaurdi pastoral station.

The MMHARCP is vested in the Conservation and Parks Commission of Western Australia and managed by the Department of Parks and Wildlife (DPaW) for the purpose of:

> *"recreation by members of the public as is consistent with the proper maintenance and restoration of the natural environment, the protection of indigenous flora and fauna and the preservation of any feature of archaeological, historic or scientific interest".*

The MMHARCP is classified as an 'other than class A' reserve, which means that activities such as mining can be carried out under the *Mining Act 1978* (Mining Act) (WA) with the approval of the Minister for Mines in consultation with the Minister responsible for the reserve, in this case the Minister for Environment, and the vested Authority (Conservation and Parks Commission).

The Mining Act consent process described above does not override assessment under the EP Act or decision by the Minister for Environment as the Minister responsible for the EP Act.

MRL will comply with mine closure obligations under the Mining Act and associated best practice regulatory standards that mitigate the impact of mining activity.

1.3 Site History

1.3.1 Mining

Mineral exploration in the southern Yilgarn dates back to the late 1800s when both gold and iron ore were first discovered. Although iron ore was discovered at the southern Koolyanobbing Range in 1887 it wasn't until 1950 that mining by the Wundowie Iron and Steel Industry commenced (Cliffs Asia Pacific Iron Ore Pty Ltd, 1993; 2015b)

A decade later Broken Hill Proprietary (BHP) acquired the mining leases for the southern Koolyanobbing Range and expanded mining operations significantly, leading to the establishment of the Koolyanobbing town site in 1965.

In 1969 and 1970 BHP undertook exploration drilling for iron ore in the HAR, specifically at Bungalbin Central and Bungalbin East, about 50 kilometres north of the southern Koolyanobbing Range.

BHP's Koolyanobbing Range operation was shutdown in 1983 following closure of the Kwinana blast furnace the previous year. Nine years later Portman Resources NL acquired BHP's former mining leases over the southern Koolyanobbing Range, in response to advertising by the WA State Government for expressions of interest in reinvigorating the Koolyanobbing Range mine operations (Cliffs Asia Pacific Iron Ore Pty Ltd, 1993; 2015b).

Portman Resources NL (Portman), in a joint venture with Heron Resources (Heron), undertook exploration drilling for iron ore at J5 in the Mt Jackson Range during 2005 and 2006. Heron's iron ore assets, which included various exploration and mining tenements in the Mt Jackson Range and the HAR, were subsequently acquired by Polaris Metals NL (Polaris) in 2006.

Portman was later acquired by Cliffs Asia Pacific Iron Ore Pty Ltd (Cliffs), which expanded operations to include additional mines in the Koolyanobbing Range as well as the Windarling and Mt Jackson Ranges. Cliffs currently produces 11 million tonnes of iron ore per year from its Yilgarn operations (Cliffs Asia Pacific Iron Ore Pty Ltd, 2015b).

MRL acquired Polaris in 2010 and has taken the company from its beginnings as junior iron ore explorer to a medium-sized iron ore producer with operations commencing at Carina in 2011 and then at J4 in 2015.

1.3.2 Conservation

The conservation value of the Mt Manning Range was recognised in the 1960s and 1970s. The Mt Manning Range Nature Reserve was created in 1979 (class C). The Mt Manning Range itself was excluded from the Nature Reserve to allow mining, as this area was already designated a Mining Act Ministerial Temporary Reserve.

Recommendations to include the HAR within the Mt Manning Range Nature Reserve were made throughout the 1980s and 1990s (Environmental Protection Authority, 2013).

In 2003 the WA Government approved a proposal to mine the Windarling and Mt Jackson ranges. Central to this decision was the proposed expansion of the Mt Manning Range Nature Reserve to include the Helena-Aurora, Die Hardy, Mt Manning and part of the Mt Jackson Range together with an upgrade in the category of the reserve from “other than class A” to “class A”.

In 2004, the proposed “class A” extensions to the Mt Manning Range Nature Reserve were publicly endorsed by the Minister for Environment, Hon Judy Edwards MLA, but subsequently overturned by Cabinet a few days later. Instead, the WA Government decided to create the Mt Manning – Helena-Aurora Ranges Conservation Park (other than class A) and seek further advice from the EPA on the areas of highest conservation value in the proposed extensions.

In 2005, the current MMHARCP was gazetted and included the Mt Manning Range itself, which had previously been excluded from the Mt Manning Range Nature Reserve, as well as the HAR.

The EPA's advice on the proposed reserve extensions was published in May 2007. The EPA's recommendations included that the Mt Manning area be recognised as a biodiversity hotspot and that the areas of highest conservation value and surrounding areas be protected from mining through a variety of mechanisms including the establishment of a class A nature reserve to protect the highest priority conservation areas such as the HAR (Environmental Protection Authority, 2007).

1.3.3 BIF Strategic Review

In 2007 the WA Government published a strategic review of the biodiversity values and iron ore prospectivity on BIF ranges in the WA's Midwest and Goldfields Regions. The strategic review was intended to provide a framework for navigating environmental approvals in relation to BIF ranges.

The BIF strategic review comprised a review of the biodiversity values and iron ore prospectivity in the Midwest and Goldfields regions (within the Yilgarn Craton). It was undertaken with input from the Department of Industry and Resources (Department of Industry and Resources, 2007) and Department of Environment and Conservation (Department of Environment and Conservation, 2007) in response to:

- a growing number of BIF range iron ore exploration and mining proposals from junior and mid-tier mining companies, fuelled by forecast significantly increased global demand for iron ore
- the challenges faced by the EPA and government in addressing cumulative environmental impacts and in balancing the economic, social and regional development benefits against high conservation values associated with BIF ranges
- the limitations of Environmental Impact Assessment (EIA) under the EP Act, which occurs on a project by project basis and is constrained to only the environmental (and limited social) aspects of proposals (Government of Western Australia, 2007).

The strategic review was therefore intended to provide information to government to allow biodiversity conservation and resource utilisation decision-making in respect of mining proposals on BIF ranges. The major findings of the review were:

- Although there are significant biodiversity and mineral resources in the BIF ranges of the Midwest and Goldfields, for many ranges mineral prospectivity is not well defined and the knowledge of conservation values is not complete.
- Without an appropriate framework for decision making, State commitments to biodiversity conservation will become increasingly difficult to meet in regard to BIF ranges and the environmental approval process for developers will become increasingly problematic.
- The BIF range located with the 'south east' cluster (Mt Manning Area) (i.e. Helena-Aurora, Mt Manning, Mt Jackson, Mt Windarling, Diemals/Die Hardy Ranges and Koolyanobbing Range) are still insufficiently explored to adequately assess prospectivity but have been the subject of EPA Bulletin No. 1256 'Advice on Areas of the Highest Conservation Value in the Proposed Extensions to Mount Manning Nature Reserve (Environmental Protection Authority, 2007), which identifies very high conservation values (Government of Western Australia, 2007).

There were numerous government-endorsed actions at this time arising from the review, including the commitment to the creation of class A nature reserves or national parks over the Helena-Aurora Range, Die Hardy Range and Mt Manning Range (as generally recommended in EPA Bulletin 1256), with an indicated pre-disposition against development of these ranges.

The actions-arising also noted the government's intention to place the Bungalbin East ranges into an appropriate reserve status (e.g. conservation park or nature reserve not of class A) that will facilitate ongoing assessment of both biodiversity and prospectivity with a view to reviewing that status in 3 years in light of increased knowledge at the appropriate time.

It should be noted that the latter intention appears inconsistent with the above commitment to create a class A nature reserve or national park over the Helena-Aurora Range, as Bungalbin East is generally accepted as being part of the Helena-Aurora Range.

Several key conservation principles and guidance were also provided in the review, with an expectation that they be taken into account in environment assessments and the provision of advice to Government (Table 1-2).

TABLE 1-2: BIF STRATEGIC REVIEW – PRINCIPLES AND GUIDELINES

Principle
1. No development activity to proceed in the Yilgarn Craton BIFs that would result in the IUCN Threat Category of any given plant or animal taxon increasing i.e. initially not being threatened under any category to being listed (the three IUCN categories for threatened species being Vulnerable, Endangered and Critically Endangered), or increasing from Vulnerable to Endangered, or from Endangered to Critically Endangered.
2. No development activity to proceed in the Yilgarn Craton BIFs that would result in the IUCN Threat Category of any ecological community increasing from not being listed as threatened under any category to being listed, or where already listed (or qualifying for listing) as a TEC, having its actual or recommended Threat Category increase (i.e. from Vulnerable to Endangered or from Endangered to Critically Endangered).
3. 15%-30% of the total number of ranges should be reserved in their entirety, protecting complete examples of the landform and ecosystem. Examples of the most outstanding BIF ranges should be protected in their entirety where development has not significant progressed, e.g. the Helena-Aurora Range (consistent with recommendations in EPA Bulletin 1256). The initial objective should be to conserve 15% of ranges in their entirety. The DEC has completed 2 years of a 3 year flora survey program, and, when completed, a review should be undertaken to further define the list of ranges requiring reservation in their entirety, with the objective of achieving at least the 30% target.
Guidance
1. Conservation reserves should include at least 60% of largely contiguous ecosystem habitat for each of the key banded ironstone species and ecological communities which are restricted to the BIF ranges.
2. Subject to key conservation principles i and ii above, an objective of detailed mine-site planning and assessment should be to maximise the protected area of any floristic community identified by detailed flora survey to be restricted to the BIF, or dependent on the BIF for its conservation. This would indicate that no development should occur in those floristic communities that are likely to be significant for the maintenance of long term viability of threatened species and threatened ecological communities.
3. Landscape, geodiversity, Aboriginal heritage values and potential for nature based tourism should be taken into account in developing a reserve system. State, national and international assessment methodologies and criteria should be used for identifying areas of significant landscape, geodiversity, Aboriginal heritage values and tourism potential for protection.

It should be noted that the actions proposed following the BIF review have not occurred and that WA Government policy in respect of the Mt Manning area, as announced in 2010 (see **Section 1.3.4**), superseded actions proposed at the time.

1.3.4 Current WA Government Policy announced in 2010

In 2010 the WA Government announced new nature conservation and mining arrangements for the Mt Manning area that was intended to provide a balanced way forward to address conservation and mining values in the area. Consistent with these new arrangements, the conservation tenure and extent of the MMHARCP remained unchanged (other than class A) (Figure 1-4).

In a joint statement, the then Minister for the Environment, the Hon Donna Faragher MLC noted that:

> *"Any development proposals in the area will continue to be subject to the requirements of the Environmental Protection Act 1986 and Mining Act 1978 which includes assessment and advice from the EPA."*

Further, the then Minister for Mines and Petroleum, Hon Norman Moore, said:

> "*We are confident that this co-operative, strategic approach will enable the region to meet its economic potential, while ensuring that significant conservation values are properly managed".*

1.4 Proposal justification and objectives

MRL has established itself as a medium sized West Australian iron ore producer with operations in the Pilbara and Yilgarn areas of Western Australia. MRL's Yilgarn operations are located 100 km north of Southern Cross.

In the Yilgarn, mining recently transitioned from Carina to J4 with the commencement of mining at J4 in August 2015 and the completion of mining at Carina in April 2016. The smaller Carina Extended deposit was approved for mining in 2013 and may be mined in 2017, subject to economic conditions. Current export rates are 5.4 million tonnes per year, all of which is transported by road then rail to Fremantle Port (Kwinana) for export to Asian steel markets.

MRL plans to extend the life of its Yilgarn operations by up to 15 years by leveraging established infrastructure and mining nearby deposits at J5 and Bungalbin East. The Proposal significantly extends the life of MRL's Yilgarn operations by recovering up to 65-115 million tonnes of iron ore. In doing so, the Proposal will help sustain the regional economy, create a positive environmental, social and economic legacy and deliver benefits that radiate beyond the region. Should the Proposal not proceed, the jobs and royalties associated with MRL's operations will cease to exist beyond 2017.

MRL's Yilgarn operations have the potential to make a strong contribution to the WA economy including several hundred million dollars of royalties, port charges and payroll tax paid to the State over the life of the operations, the ongoing direct employment of hundreds of employees and contractors as well as a multiplier of flow-on indirect benefits.

The Proposal will have an impact on the environmental values of the HAR and the broader MMHARCP, primarily in relation to conservation value associated with threatened and priority flora that are restricted to the range.

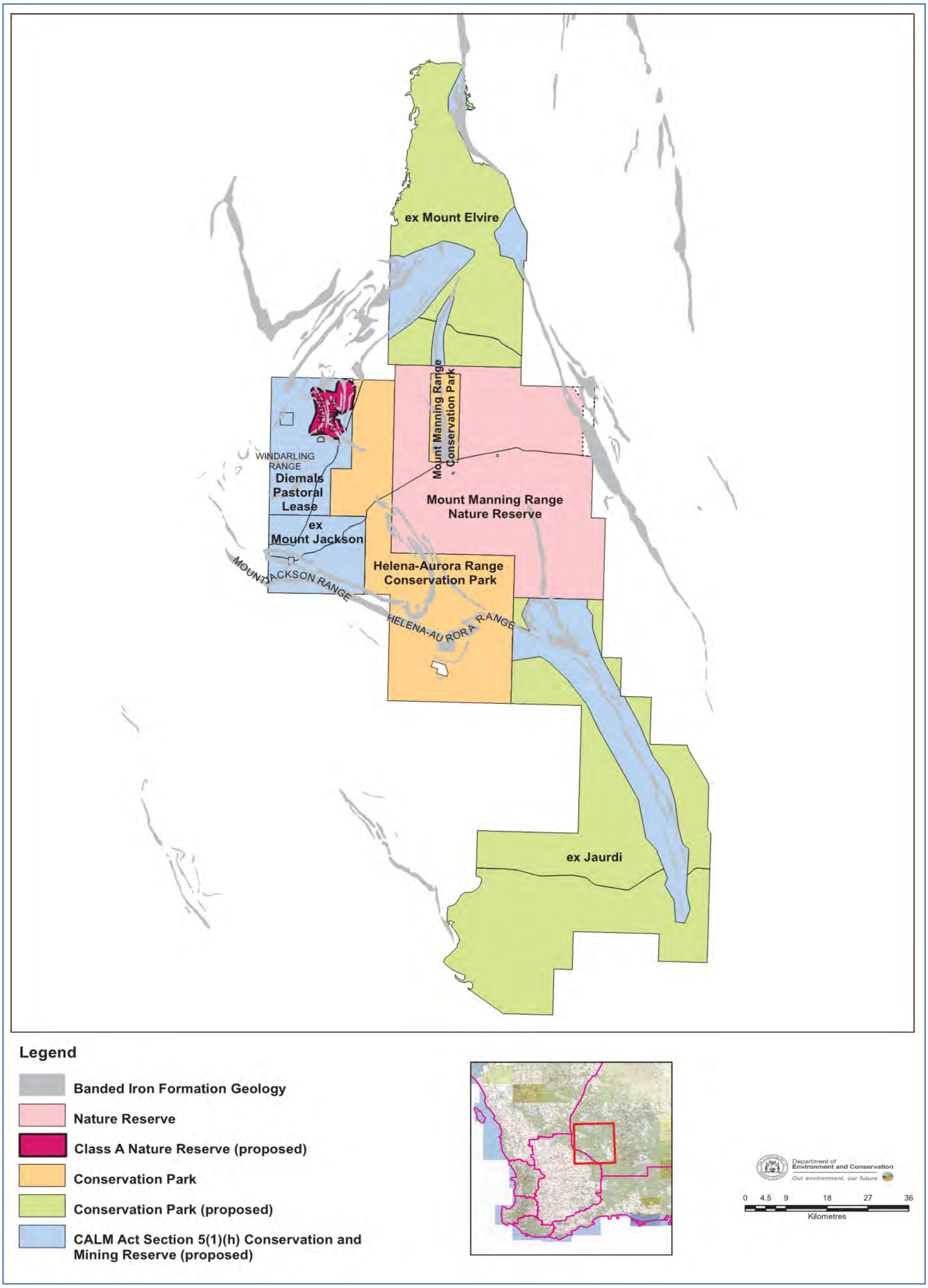

FIGURE 1-4: PROPOSED TENURE IN THE MT MANNING AREA

MRL proposes to offset the impact on these environmental values by contributing towards:

- off-site rehabilitation of historic mineral exploration disturbance within the HAR affecting high value vegetation, and
- preparation and implementation of an interim recovery plan for *Tetratheca aphylla* subsp. *aphylla* and a research plan and interim recovery plan for *Lepidosperma bungalbin.*

It is the responsibility of Government to plan for the long term future of regional WA. Given the economic and social challenges facing the Mid-West and Yilgarn regions, it is essential to take an evidence based approach to decisions on development to ensure the sustainability of the region.

MRL recognises the need for responsible environmental stewardship to support sustainable economic development and our communities. That is why our environmental management measures and offsets have been developed with the aim of creating a net environmental benefit.

The potential significant residual impacts from the Proposal are counterbalanced by appropriate conditioning and offsets and are not so great as to justify a ‘no development’ decision, which itself is not a sustainable proposition.

MRL is committed to working with DPaW to maintain and enhance visitor access and recreation opportunities within the MMHARCP as well as contributing towards management of conservation reserves in the broader region over the life of the Proposal. This will ensure that:

- the purpose for which the MMHARCP was created is not unacceptably compromised
- visitors will be able to access the HAR and enjoy a variety of recreation opportunities within a diverse landscape
- the impacts of recreation, although not environmentally significant due to the low level of visitation, can be managed to ensure beneficial conservation and recreation outcomes over the long-term.

The objectives of the Proposal are therefore to:

- contribute to the WA’s economy and in particular the local economy of Southern Cross and Kalgoorlie by purchasing mining goods and services as well as providing opportunities for local and Indigenous employment
- give back to the local communities in the Avon-Wheatbelt and Goldfields Regions by providing financial assistance and other in-kind support to community groups, charitable organisations and other non-government organisations (NGO)
- respect the conservation and recreation values of the surrounding natural environment, minimise the effect of the Proposal on the environment and actively pursue opportunities, in partnership with the DPaW, to improve protection and management of reserves in the Mt Manning area.

1.5 Environmental regulatory framework

The requirement for formal EIA and associated approval of the Proposal derives from the EPBC Act and the EP Act. With regard to EIA of the Proposal there is a suite of overarching legislation and guidance that is relevant to each of the preliminary key environmental factors under assessment, as shown in Table 1-3.

In addition to formal EIA and associated Commonwealth and WA approvals, there are several other key WA environment and heritage approvals required to implement the Proposal including:

- a Mining Proposal and Mine Closure Plan pursuant to the Mining Act
- works approval(s) and licence(s) in relation to prescribed premises (e.g. wastewater treatment and waste disposal facilities), pursuant to Part V of the EP Act
- license(s) pursuant to the *Rights in Water and Irrigation Act 1914* (WA) for the construction of water bores and/or use of water
- consent to disturb heritage sites pursuant to the *Aboriginal Heritage Act 1972* (WA)
- licences to take protected flora and fauna pursuant to the *Wildlife Conservation Act 1950* (WA).

The process and status of the key environmental approvals required to implement the Proposal are summarised below in the context of the relevant Commonwealth and state legislation.

TABLE 1-3: OVERARCHING EIA LEGISLATION, POLICY AND GUIDANCE CONSIDERED

Legislation/Guidance	Key Aspects	Application
EPA Legislation		
Environment Protection Act 1986 (WA)	Provides a WA legal framework for the prevention, control and abatement of pollution and environmental harm as we; as the conservation, preservation, protection, enhancement and management of the environment. Part IV of the EP Act provides for the referral, to the EPA, of development proposals likely to have a significant effect on the environment.	The Proposal has been referred and is being assessed under Part IV of the EP Act. Flora and vegetation, landforms, subterranean fauna, terrestrial fauna, hydrological processes and inland waters environmental quality and amenity are preliminary key environmental factors for assessment.
EPA Policy		
Environmental Impact Assessment Administrative Procedures (2012)	Provides procedures for establishing the principles and practices of EIA under Part IV of the EP Act.	The EIA of the Proposal has been undertaken in accordance with the procedures. In particular, MRL has ensured that the EIA is consistent with Clause 5 – Principle of EIA for the Proponent. The information contained in the PER is also consistent with Clause 10.2.4 – Information Requirements for the Environmental Review (PER).
Environmental Assessment Guideline 8: Environmental Principles, Factors and Objectives.	Describes the EPA's framework for environmental principles, factors and associated environmental objectives, how they link to EPA guidance and how the EPA expects them to be applied through EIA.	The EAG 8 framework has been used to assess the impact of the Proposal according to the preliminary key environmental factors specified in the ESD, as well as the object and principles of the EP Act, broader environment policy and the

Legislation/Guidance	Key Aspects	Application
		interconnectedness of the environment. The PER seeks to demonstrates that the Proposal is consistent with the principles and can meet the objective for each environmental factor.
Environmental Assessment Guideline 9: Application of a Significance Framework in the EIA Process	Describes how the EPA makes decisions throughout the EIA process on the likely significance of impacts of a proposal, using a risk based approach.	The assessment of the Proposal considers the extent to which it is consistent with the framework of environmental principles and policies, environmental factors and associated objectives and relevant guidance material – this is the basis for the EPA's determination of the likely significance (i.e. the significance test) and acceptability of the Proposal.
Non-EPA legislation, policy and guidelines		
Environment Protection and Biodiversity Conservation Act 1999 (Cth)	Provides a national legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined as matters of national environmental significance.	Referral and assessment of the Proposal pursuant to the EPBC Act is being undertaken by the EPA on behalf of the Australian Government. Refer to **Section 1.5.1** for further details of the EPBC Act assessment process.
Environmental Protection and Biodiversity Conservation Regulations 2000 (Cth);	Subordinate legislation to the EPBC Act that prescribes the manner in which certain activities are to be conducted, including environmental assessment, and how the management of certain aspects of the environment are to be undertaken.	The Proposal is being assessed under a bilateral agreement whereby the impacts to matters of national environmental significance will be assessed by the EPA on behalf of the Australian Government.
Significant Impact Guidelines 1.1 – Matters of National Environmental Significance	Provides overarching guidance on determining whether an action is likely to have a significant impact on a matter protected under national environment law – the EPBC Act	These guidelines have been considered in the assessment of the impact of the Proposal on EPBC Act listed threatened species. Refer to **Section 14** for further details.

1.5.1 *Environmental Protection and Biodiversity Conservation Act 1999* (Cth)

On 29 April 2015 the Proposal was referred to the Australian Government Department of the Environment and Energy (DEE) pursuant to the EPBC Act. It was subsequently determined to be a controlled action with the relevant controlling provision being "listed threatened species and communities (s18 and 18A)", namely:

- Critically endangered Ironstone Beard-heath (*Leucopogon spectabilis*).
- Vulnerable Bungalbin Tetratheca (*Tetratheca aphylla*).
- Vulnerable Malleefowl (*Leipoa ocellata*).

The potential impacts of the Proposal on these species will be assessed by the EPA on the Australian Government's behalf under the Bilateral Agreement between the Commonwealth of Australia and State of Western Australia made under s45 of the EPBC Act.

The Australian Government Minister for the Environment and Energy will make an approval decision informed by the EPA's Report, the WA Ministerial Approval Statement and consultation with the WA Minister and the OEPA.

1.5.2 *Environmental Protection Act 1986* (WA)

On 16 May 2014 MRL referred the Proposal to the EPA pursuant to Section 38 of the EP Act.

On 26 November 2014 the EPA made a decision to assess the Proposal and set a level of assessment of "Assessment on Proponent Information Category B (Environmentally Unacceptable)" (API- B).

On 7 January 2015 the EPA provided its report and recommendations in respect of the Proposal (Report 1537) to the Minister for Environment. This report was published on 12 January 2015 and numerous appeals were submitted to the Office of the Appeals Convenor in respect of the report.

On 22 April 2015, following consideration of the appeals, the Minister for Environment remitted the Proposal back to the EPA pursuant to Section 101(1)(d)(i) of the EP Act and directed that the EPA assess the Proposal more fully and more publicly in the form of a PER.

On 21 May 2015 the EPA considered the Proposal at EPA Meeting No. 1078 and determined that the PER document would be subject to an 8 week public advertising period and that the EPA would prepare the Environmental Scoping Document (ESD) as the basis for the PER. The EPA also determined the preliminary key environmental factors to be included in the ESD:

- Flora and vegetation
- Landforms
- Subterranean fauna
- Terrestrial fauna
- Hydrological processes and inland waters environmental quality
- Amenity
- Heritage
- Offsets
- Rehabilitation and decommissioning

On 20 August 2015, at EPA Meeting No. 1081, the EPA considered and approved the ESD for the Proposal as an acceptable basis for the preparation of the PER document (**Appendix 1-B**). A checklist of the ESD items against the content of the PER is provided in **Appendix 1-C**.

Following an eight week public advertising period of the PER, the EPA will formally assess the Proposal and prepare its report and recommendations to the Australian Government Minister for the Environment and Energy and the WA Minister for Environment as to whether the proposal should be implemented and if so, whether there should be any conditions of approval.

Section 45(1) requires the WA Minister for Environment to consult with other State decision-making authorities (DMAs) and, if possible, agree on whether the Proposal may be implemented and if so, what conditions and procedures should apply to implementation. DMAs are public authorities empowered by law or other statutory agreement to make a decision in respect of the Proposal. The DMAs identified for the Proposal are listed in Table 1-4.

TABLE 1-4: DECISION-MAKING AUTHORITIES

Decision-Making Authority	Approval
Minister for Mines and Petroleum	• *Mining Act 1978* • Grant of tenure
Minister for Environment	• *Environmental Protection Act 1986* • *Wildlife Conservation Act 1950* • Taking of protected flora and fauna
Minister for Water	• *Rights in Water and Irrigation Act 1914* • Licences for construction of bores and use of water
Minister for Aboriginal Affairs	• *Aboriginal Heritage Act 1972* • s18 consent
Director General, Department of Environment Regulation	• *Environmental Protection Act 1986* • Works approval and licence
Director General, Department of Mines and Petroleum	• *Dangerous Goods Safety Act 2004* • Storage and handling of hazardous materials • *Mines Safety and Inspection Act 1994* • Mine Safety
Director Environment Division, Department of Mines and Petroleum	• *Mining Act 1978* • Mining Proposal and Mine Closure Plan • Tenement conditions

1.5.3 *Mining Act 1978* (WA)

The Proposal is located on mining tenements M77/1095 (granted), M77/1096 (granted), M77/1097 (pending), general purpose lease G77/124 (pending) and miscellaneous licences L77/253 (pending), L77/270 (pending) and L77/269 (pending) (**Figure 1-2**).

A Mining Proposal and Mine Closure Plan will be provided to the Department of Mines and Petroleum. It will be prepared in accordance with the Guidelines for Mining Proposals (Department of Mines and Petroleum, 2006) and the Guidelines for Preparing Mine Closure Plans (Department of Mines and Petroleum / Environmental Protection Authority, 2015).

1.5.4 *Rights in Water and Irrigation Act 1914* (WA)

Licenses will be sought from the Department of Water to construct and operate at least two water bores (one at each mine site) to supply water for dust suppression and potable water requirements at the mine sites.

1.5.5 *Aboriginal Heritage Act 1972* (WA)

Aboriginal heritage surveys have been completed for the Proposal and consent under Section 18 is being sought with regard to the proposed disturbance of several heritage places at J5 and Bungalbin East.

1.5.6 *Wildlife Conservation Act 1950* (WA)

Licences will be sought from the DPaW in respect of taking protected flora and fauna as part of implementation of the Proposal.

1.6 Stakeholder consultation

MRL has developed strong connections through areas affected by the Proposal, recognising the importance of stakeholder and community consultation regarding development of the Mt Manning area, and more broadly as a key component of the environment assessment process.

Key stakeholders with an interest in the proposal include government bodies such as EPA/OEPA and DPaW and NGOs such as the Wilderness Society and the Wildflower Society of WA. Key communities include those of Southern Cross and Kalgoorlie, as well as Traditional Owners (Kaparn and Kelamaia Kabu(d)n peoples), recreational groups and private individuals.

Further details regarding the government agencies, NGOs and communities that MRL has consulted with regarding the Proposal are provided in **Table 1-5**. Stakeholder and community issues and concerns about the Proposal have been noted, together with any changes to the Proposal and/or the assessment of impacts that have occurred in response to these issues and concerns.

Consultation with government agencies has been ongoing since 2012 via correspondence, meetings and telephone conversations, primarily with the Office of the EPA (OEPA) and the DPaW, but also with the Department of Mines and Petroleum and the Department of Aboriginal Affairs.

Consultation with the OEPA has mainly related to requirements for technical studies, including the technical aspects relating to how the studies will be undertaken and requirements for peer review. It has also included general matters in relation to the conduct of the assessment, including discussion on offsets (which has been deferred until later in the assessment process).

Consultation with DPaW has focussed on technical aspects of the biological (flora and fauna), landform and visual amenity investigations.

Consultation with NGOs and communities to date has occurred via:

- Yilgarn project update meetings in 2013 with the Wilderness Society, the Wildflower Society of WA and the Helena and Aurora Range Advocates Inc – the Wildflower Society of WA was also represented at the Southern Cross community information session held in May 2015 (see below)
- community information sessions held in both Southern Cross (May 2015 and August 2016) and Kalgoorlie (November 2015) that were widely advertised in relevant newspapers including the Southern Cross Times, the Kalgoorlie Miner and the West Australian
- a targeted visitor use survey of the Mt Manning – Helena-Aurora Ranges Conservation Park undertaken during June 2016
- quarterly newsletters distributed to Southern Cross residents and available on community noticeboards and the Shire of Yilgarn in Southern Cross (August 2015, November 2015, February 2015 and May 2016)

TABLE 1-5: STAKEHOLDER CONSULTATION, ISSUES AND RESPONSES

Organisation/ Community	Consultation and issues raised	MRL Response
Government agencies		
Department of Mines and Petroleum (DMP)	29 July /2016 MRL met with the Environment and Geotechnical divisions of DMP regarding the positioning of abandonment bunds. Without EP Act approvals that this PER seeks, MRL has not had the opportunity to conduct the detailed geotechnical drilling that we would normally undertake. As such a conservative and staged approach to geotechnical stability is required.	Abandonment bunds will be constructed at the inside edge of the proposed disturbance area to prevent inadvertent public access to open pit workings. Immediately following approvals, MRL will conduct the necessary detailed geotechnical drilling to confirm how close mining can safely approach the abandonment bunds without creating potentially unstable rock mass now or into the long term future. In the interim, while this detailed information is being analysed, MRL will ensure that all mining will be stood back from the edge of the Proposal disturbance area and that any interim pit walls will be designed at very conservative angles. The stand back distances, pit wall angles and pit designs will be agreed with sign off from consultant geotechnical engineers and managed under DMP's Project Management Plan and Mining Proposal approval processes for both the interim pit designs and the final pit designs. Mining will only progress closer to the abandonment bunds once the necessary geotechnical work confirms the long term stability of the rock mass to DMP's satisfaction. This will not only manage future public safety, but also ensure that rare flora adjacent to the pit disturbance area is not at risk on potentially unstable rock mass.
	21 July 2015 Meeting to discuss approach to waste characterisation for the Rehabilitation and decommissioning factor in the PER, in	MRL provided DMP with a methodology for a risk-based waste characterisation, which was accepted by the DMP as a suitable

Organisation/ Community	Consultation and issues raised	MRL Response
	response to the draft ESD provided to MRL for review and comment.	approach for the PER – the draft ESD was subsequently revised.
	11 February 2014 Meeting to discuss tenure arrangements for supporting mine infrastructure at Bungalbin East.	Modifications to the proposal to reduce disturbance to the range – waste dump and supporting infrastructure relocated further away from the range - required additional tenure beyond M77/1097 for these components.
	1 October 2013 Meeting to provide an update on MRL's Yilgarn operations and proposed operations.	No change to the Proposal.
Environmental Protection Authority (EPA)	20 August 2015 EPA Board meeting at which the ESD specifying the scope and content of the PER document was considered and approved by the EPA as providing an acceptable basis for the preparation of the PER document.	No change to the Proposal.
	11 December 2014 EPA Board meeting at which MRL presented details of the Proposal for the purpose of the EPA's decision regarding whether to assess the Proposal and, if so, the level of assessment.	MRL has undertaken many changes to the Proposal since this meeting, all of which have been designed to reduce the environmental impact of the Proposal.
	21 November 2013 Meeting with EPA Chairman to discuss MRL's Yilgarn projects, particularly J5 and Bungalbin East. The EPA Chair noted the challenges for proposed development within the MMHARCP.	No change to the Proposal.

Organisation/ Community	Consultation and issues raised	MRL Response
	29 February 2012 Meeting with EPA Chairman to discuss MRL's proposed activities in the greater Mt Manning area. EPA advised MRL regarding its expectations for proposed exploration and development, including the need for environmental investigations and analysis to meet the relevant EPA guidelines.	MRL has liaised with DPaW regarding methods for flora and fauna surveys, as part of the baseline studies underpinning the Proposal.
Office of the Environmental Protection Authority (OEPA)	2014-Present Ongoing consultation with the OEPA as part of the Part IV EP Act referral and assessment process.	Refer to Section 2.6 for details of the alternatives considered and changes made the Proposal since referral to the EPA.
	3 October 2012 Meeting with OEPA and DPaW to discuss botanical survey methods for BIF ranges.	Survey requirements addressed as part of baseline flora and vegetation surveys undertaken 2012-2013.
	27 August 2012 Meeting with OEPA and DPaW to discuss SRE survey methods.	Survey requirements addressed as part of baseline SRE surveys.
Conservation and Parks Commission	10 September 2012 Presentation to the Conservation Commission by Department of Environment and Conservation (DEC) on behalf of Polaris regarding proposed exploration activities at J5 and Bungalbin East. The Conservation Commission noted the presentation provided by DEC and advised that it did not support the exploration proposal on the Helena-Aurora Range within the MMHARCP.	The Proposal is not able to be modified to accommodate this position.
Department of Parks and Wildlife	16 June 2016 Meeting with DPaW to discuss advice received from OEPA and	Further work has been undertaken as per the meeting outcomes,

Organisation/ Community	Consultation and issues raised	MRL Response
(DPaW)	DPaW on the draft methodology and site selection for the Visual Impact Assessment (VIA). Key issues included: • Additional background sites (particularly from Mt Manning Range) and middleground sites along the southern boundary of the reserve and at Mt Dimer bypass will be included in the VIA. • Additional information on travel routes and travel experience along the four main access routes to the HAR will be included. • the updated VIA report will be amended to present the information collected more in alignment with the recommendations of the peer reviewer (e.g. more maps showing the broader level, landscape character units and visitor experiences and key locations. • Extent of visual impact, key views impacted and changes to view experience need to be mapped and described.	with revisions captured in the revised VIA report and the revised PER.
	<u>29 October 2015</u> Meeting with DPaW (Kalgoorlie) to provide an update on MRL's Yilgarn operations and proposed operations and to informally discuss offset opportunities.	No change to the Proposal.
	<u>15 April 2014</u> Meeting with DPaW to provide an update on MRL's Yilgarn operations and proposed operations including J5 and Bungalbin East.	No change to the Proposal.

Organisation/ Community	Consultation and issues raised	MRL Response
	3 October 2012 Meeting with DPaW, OEPA, DMP to discuss botanical survey methods for BIF ranges.	Survey requirements addressed as part of baseline flora and vegetation surveys undertaken 2012-2013.
	27 August 2012 Meeting with DPaW, OEPA and DMP to discuss SRE survey methods.	Survey requirements addressed as part of baseline SRE surveys.
Shire of Yilgarn	16 April 2015 MRL attended Council meeting and provided an update on MRL's Yilgarn operations and proposed operations including J5 and Bungalbin East.	No changes to the Proposal.
	1 September 2013 Meeting with Shire of Yilgarn to provide an update on MRL's Yilgarn operations and proposed operations including J5 and Bungalbin East.	No changes to the Proposal.
Non-Government Organisations		
The Wilderness Society	10 June 2016 MRL conducted a telephone interview with the Wilderness Society regarding visitor use of the MMHARCP.	MRL has used the information from the visitor use survey to better understand visitor use within the MMHARCP and ensure that the effects of the Proposal on amenity, including visual amenity, are adequately assessed.
	14 February 2014 MRL invited the Wilderness Society via letter to meet to discuss the Proposal – no response was received.	-

Organisation/ Community	Consultation and issues raised	MRL Response
	August 2013 Meeting with the Wilderness Society to discuss MRL's Yilgarn operations and proposed operations, including J5 and Bungalbin East. MRL was advised that the Wilderness Society is opposed to all development in the area.	The Proposal is not able to be modified to accommodate the position put forward by the Wildflower Society.
Wildflower Society of Western Australia	20 June 2016 MRL conducted a telephone interview with the Wildflower Society regarding visitor use of the MMHARCP.	MRL has used the information from the visitor use survey to better understand visitor use within the MMHARCP and ensure that the effects of the Proposal on amenity, including visual amenity are adequately assessed.
	15 April 2014 Meeting with Wildflower Society and Helena-Aurora Range Advocates, who sought support from MRL for upgrading the MMHARCP to a National Park, with no mining.	The Proposal is not able to be modified to accommodate the position put forward by the Wildflower Society.
	August 2013 Meeting with the Wildflower Society to discuss MRL's Yilgarn operations and proposed operations, including J5 and Bungalbin East. MRL was advised that the Wildflower Society is opposed to all development in the area.	The Proposal is not able to be modified to accommodate the position put forward by the Wildflower Society.
Helena and Aurora Range Advocates (HARA)	15 April 2014 Meeting with HARA and Wildflower Society, who sought support from MRL for upgrading the MMHARCP to a National Park, with no mining.	The Proposal is not able to be modified to accommodation this position.

Organisation/ Community	Consultation and issues raised	MRL Response
Community		
General community	Aug-Oct 2016 This PER document will be advertised for public review and comment for a period of 8 weeks	-
	4 June 2015-19 June 2015 DEE published the referral documentation on its website for a period of 10 business days with an invitation by DEE for public submissions. One public response was received on the referral during this period, regarding the potential impact of the proposed action on two flora species listed under the EPBC Act (Ironstone Beard-heath and Bungalbin Tetratheca).	No change to the Proposal.
	2 July 2014-8 July 2014 The EPA published the referral documentation associated with the Proposal on its website for a period of 7 days, with an invitation by EPA for public submissions. A total of 1004 public submissions were received with regard to the level of assessment to be set for the Proposal (2 – Do not assess; 0- API-A; 986 – API-B; 16 – PER).	The Proposal cannot be modified to accommodate the position of respondents who nominated an API-B level of assessment.
	7 January 2015 The EPA published its report and recommendations in relation to the Proposal, thereby triggering a two week public appeal period in which public appeals on the report and recommendations were made. A total of 5 appeals were received by the Appeals Convenor, 3 of	No change to the Proposal.

Organisation/ Community	Consultation and issues raised	MRL Response
	which were proponent/industry appellants and two of which were conservation group appellants.	
Southern Cross Community	13 May 2015 Community information session held in Southern Cross attended by MRL representatives and approximately 40 stakeholders including representatives from the Shire of Yilgarn, Cliffs Natural Resources, local businesses and members of the community, as well as the Wildflower Society. Key concerns and issues included: • the potential for disturbance of flora and fauna • the potential for impact on conservation values, including intactness of the ranges. • the need for rehabilitation plans to be developed • tourism opportunities and safe public access • local employment guarantee • business opportunities in the SX community.	MRL has endeavoured to mitigate the impact of the Proposal on flora and fauna, and associated conservation values, whilst ensuring a commercially viable Proposal. A Rehabilitation and Mine Closure Plan has been developed and included with the PER, and it is expected that further refinements will be made to this plan in consultation with OEPA, DPaW and DMP. The Proposal retains public access to all areas outside the mining tenements associated with the Proposal. Further consultation with DPaW and DMP will occur to ensure continuity of safe public access to the area.
Kalgoorlie Community	28 November 2015 Community information session held in Kalgoorlie attended by MRL representatives and about 15 stakeholders including representatives from local businesses, the media and members of the community. Key concerns and issues included: • plans for rehabilitation and ensuring the environment remains intact • whether the grade of ore to mined is worth the disturbance to	A Rehabilitation and Mine Closure Plan has been developed and included with the PER, and it is expected that further refinements will be made to this plan in consultation with OEPA, DPaW and DMP. The Rehabilitation and Mine Closure Plan address the issue of whether roads are rehabilitated or handed-over consistent with the post-mining land use of the area. MRL acknowledges its historic infringements associated with its

Organisation/ Community	Consultation and issues raised	MRL Response
	the sensitive natural ecology • ensuring handover of roads post-mining rather than rehabilitate them, so they can be used for tourism and emergency services • the proponent's previous environmental infringements on its other mining leases • number of jobs to be created, use of contractors and supply tenders.	Carina operation, and has demonstrably improved its environmental management system, including the commitment to certify the Environmental Management System (EMS) for the Proposal.
Coates Wildlife Tours	20 June 2016 MRL conducted a telephone interview with Coates Wildlife Tours regarding visitor use of the MMHARCP by Coates Wildlife Tours.	MRL has used this information to inform the visual impact assessment and assessment of impacts to amenity.
WA 4WD Association	20 June 2016 MRL conducted a telephone interview with the WA 4WD Association regarding visitor use of the MMHARCP by the WA 4WD Association.	MRL has used this information to inform the visual impact assessment and assessment of impacts to amenity.
Eastern Goldfields 4WD Club	22 June 2016 MRL conducted a telephone interview with the Eastern Goldfields 4WD Club regarding visitor use of the MMHARCP by the Eastern Goldfields 4WD Club.	MRL has used this information to inform the visual impact assessment and assessment of impacts to amenity.
All Tracks 4WD Club	20 June 2016 MRL conducted a telephone interview with All Tracks 4WD Club regarding visitor use of the MMHARCP by the All Tracks 4WD Club.	MRL has used this information to inform the visual impact assessment and assessment of impacts to amenity.

Organisation/ Community	Consultation and issues raised	MRL Response
Adventure 4WD	20 June 2016 MRL conducted a telephone interview with Adventure 4WD regarding visitor use of the MMHARCP by the club.	MRL has used this information to inform the visual impact assessment and assessment of impacts to amenity.
Other individuals	June 2016 MRL conducted telephone interviews with a number of individuals regarding use of the MMHARCP.	MRL has used this information to inform the visual impact assessment and assessment of impacts to amenity.
Kaparn and Kelamaia Kabu(d)n Peoples	MRL has consulted extensively with Native Title Groups and the Champion and Sambo families. Further, as members of the Ballardong group are listed by the DAA as Registered Informants for certain Other Heritage Places within the MMHARCP, MRL has also involved them in Aboriginal heritage surveys.	The Proposal has been developed to avoid OHPs and MRL-defined cultural areas where possible.

- presentation on the Proposal to the Esperance Chamber of Commerce and Industry Annual Forum in March 2016 and the Goldfields Environmental Management Group Biennial Workshop in May 2016
- publication of relevant material on the MRL website
- a dedicated email address for community feedback in relation to MRL's Yilgarn current and proposed operations

In addition to consultation with key stakeholders and communities undertaken directly by MRL, there has also been broader community consultation throughout the EIA process to date:

- 7 day public advertising following referral of the Proposal to the EPA
- 7 day public advertising following referral of the Proposal to the Commonwealth Department of the Environment
- 14 day public appeal period on the EPA's Report and Recommendations following the initial API(B) level of assessment
- 8 week public advertising period for the PER.

It is expected that consultation with regulatory agencies and the community will be ongoing during implementation and operation of the proposal. Consultation with regulatory agencies is expected to occur via annual compliance reporting associated with statutory approvals issued and/or managed by these agencies pursuant to the relevant legislation. Consultation with the community is expected to occur via the MRL website.

1.7 Structure of this document

The PER has been prepared in accordance with the generic guidelines provided by the EPA to assist proponents in preparing environmental reviews (EPA 2012). The PER contains specific information related to the Proposal, the results of investigations, assessment of impacts, management, consultation and evaluation against environmental principles and factors.

The structure of the document consists of:

- Chapter 1 introduces the Proposal, its objectives and justification as well as the environmental regulatory framework governing its implementation.
- Chapter 2 provides a detailed description of the Proposal, including MRL's approach to environmental management.
- Chapter 3 describes the environmental setting within the Proposal will occur, focussing on site condition, biodiversity and key ecosystem processes.
- Chapter 4 describes the environmental impact assessment (EIA) framework and methods used to assess the potential impact of the Proposal on the environment as part of this PER.
- Chapters 5-11 assess each of the preliminary key environmental factors identified in the ESD for the Proposal, in terms of the relevant EPA objective and policies, existing environment, potential impacts, proposed environmental management and predicted outcome.
- Chapters 12-13 discuss the integrating environmental factors relevant to the Proposal, namely offsets and rehabilitation and decommissioning.
- Chapter 14 assesses the potential impacts of the Proposal to matters protected under the EPBC Act.

- Chapter 15 provides an evaluation of the Proposal with regard to the principles of environmental protection outlined in the EP Act.
- Chapter 16 provides a concluding discussion on the residual environmental impact of the Proposal, in the context of the object and principles of the EP Act and its overall environmental acceptability.

1.8 Study team

This document was prepared by a team of environmental professionals working together to document and assess the environmental impacts of the Proposal. The team and their respective contributions are acknowledged in Table 1-6.

TABLE 1-6: STUDY TEAM

Team Member	Contribution	Team Member	Contribution
	• PER document		• Subterranean fauna assessment • Short-range endemic invertebrate fauna assessment
	• IUCN Flora Threat Assessment • Landform Impact Assessment • Visual Impact Assessment • PER Chapter 6 – Landforms • Amenity Management Plan • PER Chapter 10 - Amenity • PER document review • Community consultation		• Seed propagation of *T. aphylla* subsp. *aphylla*
	• PER document – figures and disturbance calculations • Flora and vegetation assessment • Terrestrial vertebrate fauna		• Peer review of flora and vegetation assessment • Biodiversity modelling • Population genetics

Team Member	Contribution	Team Member	Contribution
	assessment • SRE invertebrate fauna assessment • Landform Impact Assessment • Visual Impact Assessment		
ecologia ENVIRONMENT	• Flora and vegetation assessment • Terrestrial vertebrate fauna assessment	eco logical AUSTRALIA	• Rehabilitation literature review • Draft Rehabilitation and mine closure plan
ecoscape	• Peer review of Visual Impact Assessment	talis delivering solutions	• Draft Rehabilitation and mine closure plan
The University of Western Australia Achieving International Excellence	• Peer review of Landform Impact Assessment	WOODMAN ENVIRONMENTAL	• Review of threatened and priority species and communities management • Management of conservation significant species and communities • Offsets • Rehabilitation and mine closure plan
soilwater GROUP	• Waste characterisation • Soils assessment • Rehabilitation and mine closure advice	**R & E O'Connor (Principle)** **John Cecchi Heritage Management Consultancy** **Dr Christine Mathieu** **Artefaxion Pty Ltd**	• Aboriginal heritage surveys • Review and revision of PER Chapter 11

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2. PROPOSAL DESCRIPTION

2.1 Overview

The Proposal comprises the construction, operation and closure of mining at the J5 and Bungalbin East iron ore deposits and associated infrastructure in the Mt Manning area north of Southern Cross.

Mining will be undertaken from a total of three open-cut pits across two deposits using conventional drill and blast techniques followed by excavation, loading and transport to the ore stockyard.

Stockpiled ore will be loaded onto haul trucks and transported 50 km south on dedicated haul roads to the existing ore processing facility at MRL's Carina operation. The processing facility dry-crushes and screens the ore to a suitable size for loading onto ore trains at the Mt Walton siding on the Trans-Australian railway line.

The key characteristics of the Proposal are summarised in **Table 2-1** and detailed in **Table 2-2** and **Table 2-3** in terms of the physical and operational elements of the Proposal. The key characteristics have been defined with reference to the *Environmental Assessment Guideline for Defining the Key Characteristics of a Proposal* (Environmental Protection Authority, 2012).The remainder of this section describes the Proposal in further detail.

TABLE 2-1: KEY CHARACTERISTICS - SUMMARY OF THE PROPOSAL

Proposal title	Jackson 5 and Bungalbin East Iron Ore Project
Proponent name	Mineral Resources Limited
Short description	The Proposal is to construct and operate two open-cut iron ore mines, referred to as J5 and Bungalbin East, within the Mount Manning area. The Proposal is located approximately 100 km north of Southern Cross in the Yilgarn area of WA. The Proposal includes: • three open-cut pits (one at J5 and two at Bungalbin East) • three waste rock landforms • haul roads • supporting infrastructure for each mine include internal mine access roads, the ore stockpile area, site office, workshop, laydown area, explosive magazine, water bores, water storage dam (turkey nest) for potable and operational water supply, Waste Water Treatment Plant (WWTP), Reverse Osmosis plant (RO), power supply, fuel storage, hazardous materials storage area and landfill • closure of both mines and rehabilitation of areas disturbed by mining and related activities.

TABLE 2-2: KEY CHARACTERISTICS – PHYSICAL ELEMENTS

Element	J5		Bungalbin East	
	Location	Proposed extent	Location	Proposed extent
Mine pit	**Figure 2-1** **Section 0**	Clearing no more than 61 hectares (ha) of native vegetation within a 2055 ha development envelope.	**Figure 2-1**a **Section 0**	Clearing no more than 147 ha of native vegetation within a 2055 ha development envelope.
Waste rock landform	**Figure 2-1**	Clearing no more than 88 ha of native vegetation within a 2055 ha development envelope.	**Figure 2-1**a	Clearing no more than 98 ha of native vegetation within a 2055 ha development envelope.
Supporting infrastructure	**Figure 2-1**	Clearing no more than 47 ha of native vegetation within a 2055 ha development envelope.	**Figure 2-1**a	Clearing no more than 45 ha of native vegetation within a 2055 ha development envelope.
Haul road	**Figure 2-1** **Figure 2-1**b	Clearing no more than 57 ha of native vegetation within a 2055 ha development envelope.	**Figure 2-1**a **Figure 2-1**c	Clearing no more than 68 ha of native vegetation within a 2055 ha development envelope.

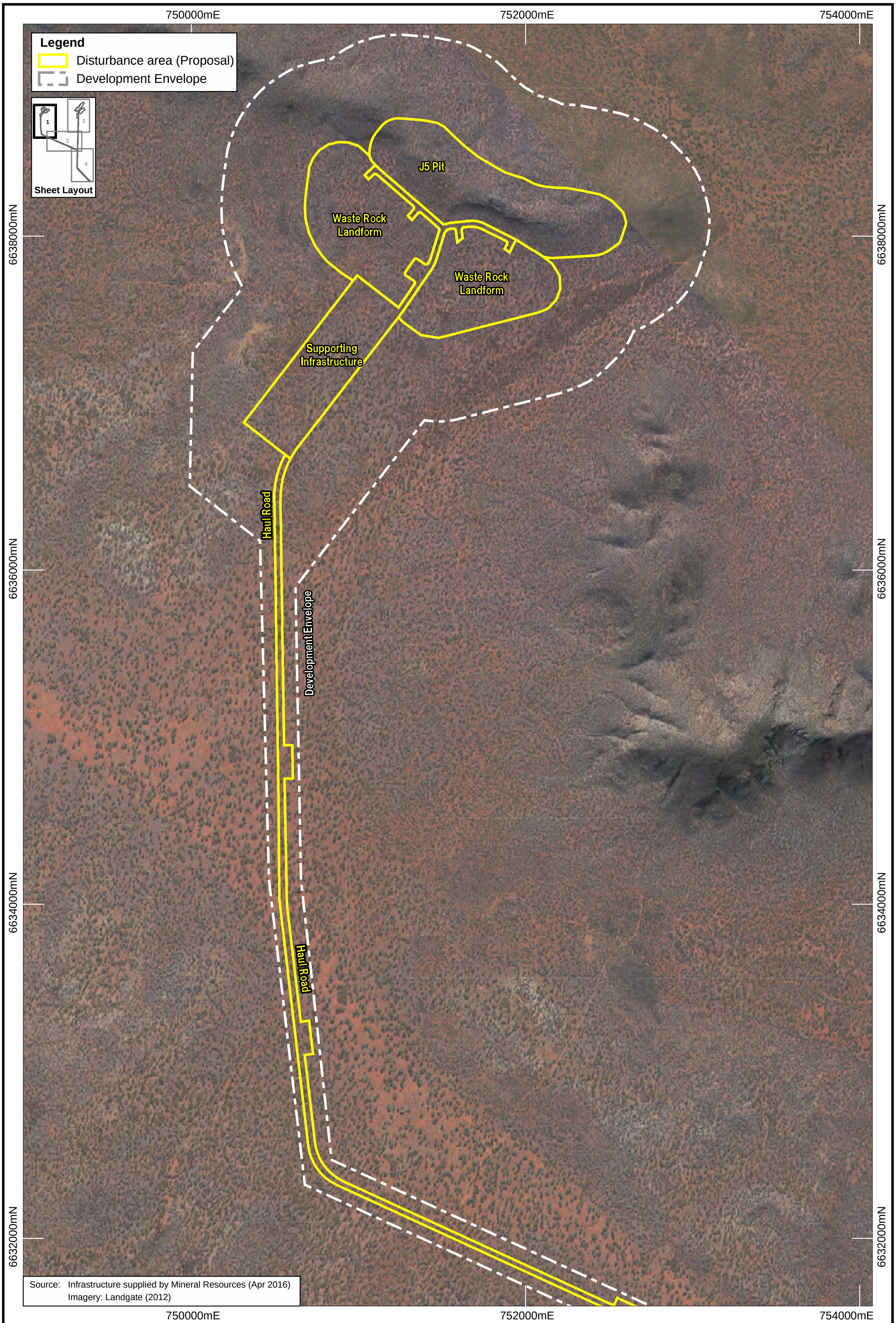
TABLE 2-3: KEY CHARACTERISTICS – OPERATIONAL ELEMENTS

Element	J5		Bungalbin East	
	Location	Proposed extent	Location	Proposed extent
Waste rock volume	**Figure 2-1**	Disposal of approximately 21 million tonnes of waste rock	**Figure 2-1a**	Disposal of approximately 70 million tonnes of waste rock
Water abstraction	Total abstraction of approximately 219,000 kilolitres per annum for construction and operational purposes.			

2.2 Construction

Construction will commence with clearing the centreline of the haul road, which will be subsequently widened to the full width of the haul road, inclusive of cut and fill requirements to maintain the design gradient.

Locations of suitable gravel material for road construction will be identified within the development envelope and these areas cleared in preparation for excavation of this material. Topsoil and vegetation will be stockpiled in suitable locations for use in rehabilitation following the completion of mining.



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CAD Ref: g2378_J5_BE_PER_C02_F02_01

Date: Jul 2016 | Rev: D | A4

Author: Mineral Resources

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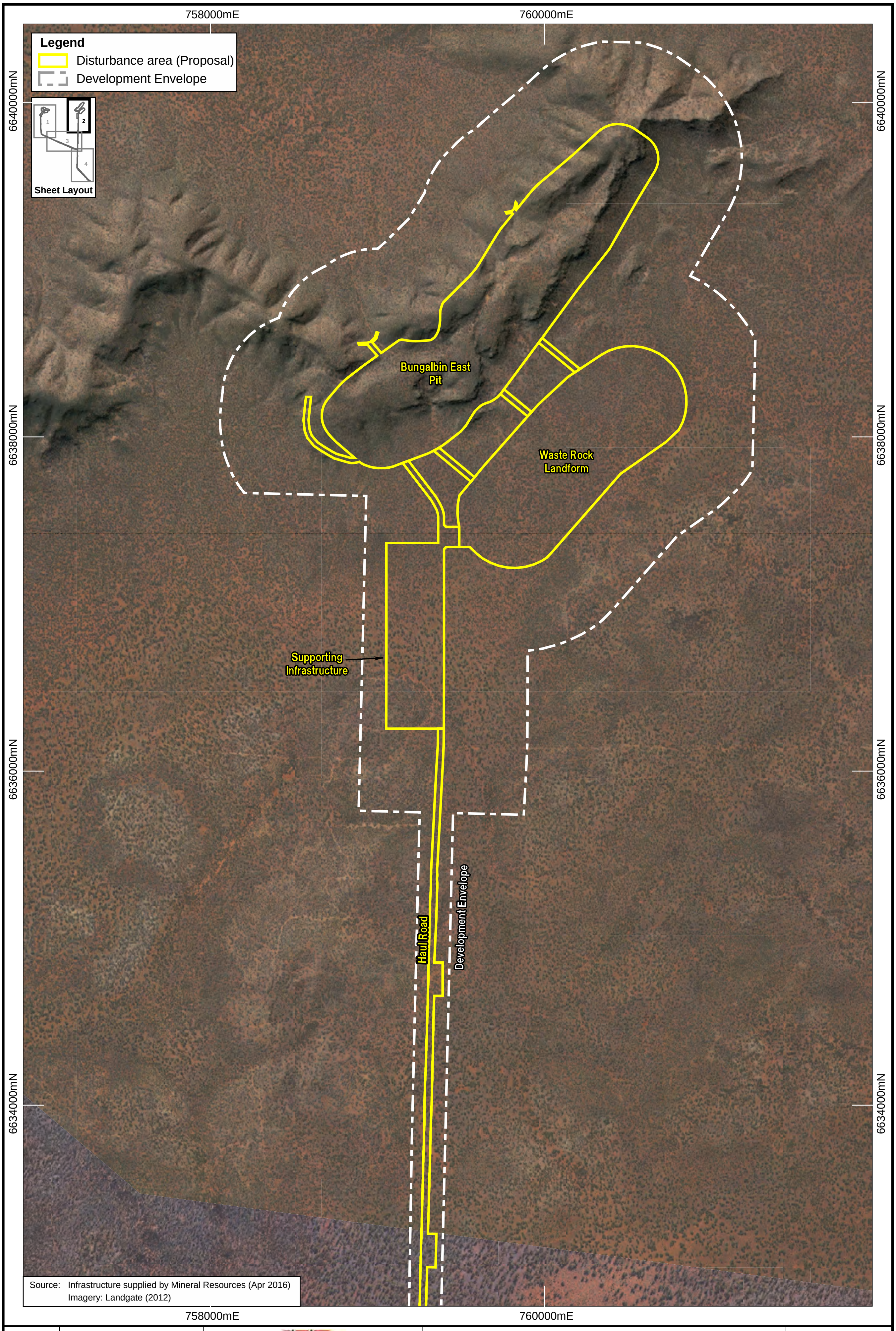
THE PROPOSAL

Figure:

2-1



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	Date: Jul 2016 | Rev: D | A4		**2-1A**

Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: Landgate (2012)

0 300 600m
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CAD Ref: g2378_J5_BE_PER_C02_F02_03
Date: Jul 2016 | Rev: C | A4

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THE PROPOSAL

Figure:
2-1B

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MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C02_F02_04

Date: Jul 2016 | Rev: C | A4

Author: Mineral Resources

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THE PROPOSAL

Figure:

2-1C

Water for construction requirements may initially be sourced from the licensed production bores at the J4 and Carina mines, and the associated pipeline installed along the J4 haul road.

Construction of the mines and supporting infrastructure will commence once the haul road has been completed to a sufficient standard allowing construction machinery to access the mine sites. Topsoil and vegetation will be stockpiled in suitable locations for use in progressive rehabilitation following the commencement of mining.

2.3 Operations

2.3.1 Mine pits

The J5 deposit will be mined from a single open-cut pit yielding a total estimated 13 to 32 million tonnes (Mt) of iron ore. The Bungalbin East deposit will be mined from two adjacent pits yielding a total estimated 52 to 83 Mt of iron ore.

At the completion of mining, the area disturbed by the pits at J5 and Bungalbin East will be 61 ha and 147 ha, respectively. This disturbance area is inclusive of areas previously disturbed by historic land use as well as areas required during and/or after mining for:

- temporary storage of cleared vegetation that will be used for progressive and post-mining rehabilitation
- temporary storage of harvested topsoil/subsoil that will be used for progressive and post-mining rehabilitation
- light vehicle access track between mine pits and stored vegetation and topsoil
- abandonment bunds where required for ongoing public safety of the area post mining.

Mining will result in the removal of approximately 75 vertical metres of rock within the pit at J5 and approximately 115 vertical metres of rock within the southern (deepest) pit at Bungalbin East. Pit dewatering will not be required at either deposit as mining will not intersect the natural groundwater elevation of approximately 420 metres (m) Australian Height Datum (AHD) at J5 and 450 mAHD at Bungalbin East.

At Bungalbin East the southern pit will be mined first and then backfilled with waste rock from the northern pit. Backfilling of the southern pit is expected to raise the floor of the pit to about the same height as the eastern side of the pit crest (refer to **Figure 12-2**).

2.3.2 Waste rock landforms

Approximately 91 Mt of waste rock will be excavated during mining, comprised of approximately 21 Mt of at J5 and approximately 70 Mt at Bungalbin East.

At J5 waste rock will be disposed of via two smaller Waste Rock Landforms (WRLs) adjacent to the pit. The WRLs are separated from each other and the mine pit by internal access roads.

At Bungalbin East, waste rock from the southern pit will be disposed of via a single WRL containing approximately 33 Mt. Waste rock from the northern pit will be backfilled into the southern pit, comprising a volume of approximately 37 Mt. The WRL and associated access roads are located to avoid conservation significant plant species where possible.

The conceptual design for the WRLs incorporates a single lift that is up to 45 m in height with concave slopes having a profile of 20 degrees at the crest grading to 15 degrees at the toe. If necessary, cells will be constructed within the centre of the WRLs to appropriately dispose of potentially acid forming or other hostile waste rock.

At the completion of mining the combined disturbance area of the WRLs at J5 and a Bungalbin East will be 186 ha, comprised of 88 ha at J5 and 98 ha at Bungalbin East. This disturbance area is inclusive of areas previously disturbed by historic land use as well as:

- temporary storage of cleared vegetation that will be used for progressive and post-mining rehabilitation
- temporary storage of harvested topsoil/subsoil that will be used for progressive and post-mining rehabilitation
- light vehicle access tracks between the WRLs and stored vegetation and topsoil.

2.3.3 Supporting infrastructure

Supporting infrastructure for each mine includes internal mine access roads, the ore stockpile area, site office, workshop, laydown area, explosive magazine, water storage dam (turkey nest) for potable and operational water supply, WWTP, RO plant, power supply, fuel storage, hazardous materials storage area and landfill.

At the completion of mining the total area disturbed by supporting infrastructure at J5 and Bungalbin East will be 92 ha, comprised of 47 ha at J5 and 45 ha at Bungalbin East. This disturbance area is inclusive of areas previously disturbed by historic land use as well as temporary storage of cleared vegetation and harvested topsoil/subsoil that will be used for post-mining rehabilitation of these areas.

2.3.4 Haul roads

A total of 30 km of haul road will be constructed to connect the mine operations to the J4 haul road. The haul road network extends generally south from the deposits along L77/253 (incorporating a small diversion, being L77/270) to meet the J4 haul road on L77/254.

At the completion of mining the total area disturbed by haul roads will be 125 ha, comprised of 57 ha at J5 and 68 ha at Bungalbin East. This disturbance area includes allowances for:

- temporary storage of cleared vegetation, topsoil and subsoil that will be used as part of post-mining rehabilitation
- gravel pits for road-base material as well as long-term maintenance of unsealed mine roads
- road drainage through the installation of v-drains and catch-ponds where necessary
- maintenance of surface water flow during flood events through the installation of pipes and/or culverts as necessary
- water pipelines and telecommunications infrastructure (e.g. fibre-optic cable and communications towers) as required.

2.4 Closure

The closure phase of the Proposal comprises the decommissioning and removal of all built infrastructure and rehabilitation of all remaining disturbance associated with the Proposal. Rehabilitation and decommissioning will be undertaken in accordance with the Rehabilitation and Mine Closure Plan. Further detail on rehabilitation and decommissioning is provided in **Section 12**.

In the interest of public safety, abandonment bunds will be constructed across mine roads and other access tracks that intersect the pits, to prevent the possibility of inadvertent vehicle access to these areas.

Where there is steep terrain and an absence of mine roads or access tracks the potential safety risk from inadvertent vehicular access is low, but allowance has been made for the construction of an abandonment bund within the disturbance area.

MRL has consulted with the DMP regarding the positioning of abandonment bunds, noting that detailed geotechnical drilling to confirm the stability of the pit walls post mining has not been possible at this time due to access restriction. This geotechnical drilling will occur immediately following approval to confirm how close mining can safely approach the abandonment bunds thereby ensuring long-term stability of the final landform.

2.5 Existing facilities

The Proposal will utilise existing facilities associated with the J4 and Carina operations, these being the J4 haul road, the Carina accommodation village, the Carina haul road, the Carina airstrip and the processing and rail load-out facilities at the Carina operation.

A new accommodation village will be constructed at the intersection of the J4 and proposed Bungalbin East haul roads, outside of the MMHARCP. This village is approved under Ministerial Statement 988 in relation to the J4 proposal and the changes to that proposal approved under s45C of the EP Act. The village was not constructed to support the J4 operation for economic reasons. Whilst the new camp is under construction, the existing Aurora camp on M77/580 will be utilised to accommodate a construction workforce of up to 110 personnel, prior to the Aurora camp being decommissioned.

Both the Carina and J4 mines and associated infrastructure operate pursuant to approvals obtained under relevant legislation. The aspects of these operations that are necessary for the implementation of the Proposal, such as the processing and rail load-out facilities, haul roads, accommodation village and airstrip can be managed under existing approvals under Part IV of the EP Act and therefore do not form part of the Proposal.

2.6 Alternatives considered

MRL has undertaken a detailed evaluation of options or alternatives in locating, planning and designing the Proposal to mitigate environmental impacts.

This evaluation began prior to the development of MRL's Carina operation in 2011, when strategic planning was undertaken with regard to the future development of all of MRL's iron ore deposits in the Yilgarn, including Carina Extended, Chameleon, Hunt Range, J4, J5 and Bungalbin East.

The 'no development' alternative is not a realistic proposition for MRL due to the significant investment it has made in the Yilgarn region for the benefit of shareholders, employees, local communities and the State of WA. In any case, the significance of residual impacts of the Proposal are not so great as to justify a 'no development' decision.

Exercise of the 'no development' alternative is more appropriately achieved through Government policy. As no such policy exists in any tenements and their associated mineral exploration and mining entitlements that were to be relinquished by MRL would inevitably be secured by others.

Mining of iron ore deposits in the Yilgarn is typically carried out using a central infrastructure hub, often attached to a mine, which receives and processes ore from one or more 'satellite' mines in the region prior to rail load-out to a port facility. Haulage of ore from satellite mines to the central processing hub is typically done by haul trucks operating on a dedicated haul road, with rail transport inevitably being excluded on the basis of the relatively high up-front capital cost of construction that cannot be recovered over the life of the Proposal.

By implementing the model outlined above, MRL is able to minimise the cumulative environmental impact of mining as ore processing facilities are not required to be constructed at each satellite mine and other approved infrastructure such as segments of haul roads constructed as part of other proposals will be utilised.

The haulage routes between J4, J5, Bungalbin East and MRL's central processing hub at Carina were carefully evaluated, particularly with respect to the MMHARCP. Two main haul routes were considered:

- Continue the Carina haul road in north-westerly direction to connect the Carina Extended, Chameleon and Hunt Range deposits and then in a westerly direction along the northern side of the Helena-Aurora Range to connect J4, J5 and Bungalbin East.
- Branch off the Carina Haul Road about 10 km south of the Carina mine in a westerly direction to connect with J4, with additional spurs along the way in a northerly direction to connect to J4 and Bungalbin East.

The latter of these two options was ultimately selected on the basis that J4 would be developed first and that this option would minimise the extent of the haul road network, and therefore disturbance, within the MMHARCP. In doing so, the haulage distance between J4, J5, Bungalbin East and the central processing hub was increased at MRL's cost, in terms of the length of haul road to be constructed as well as the ore haulage distance.

In terms of the sequence of development for the Proposal, it should be noted that the mines will be developed simultaneously once mining at J4 is complete. Ore from J5 is required to be blended with ore from Bungalbin East to achieve the correct product specification; therefore J5 is unlikely to be mined in isolation from Bungalbin East.

MRL has invested considerable effort in site design and layout to optimise the Proposal so as to minimise environmental impact. The process of optimisation has focussed on the location and design of WRLs, supporting infrastructure and haul roads. This is because these elements, as compared to the mine pits, are more capable of being located and/or designed to avoid or minimise environmental impacts. The ore deposits, and the pits required to be excavated to recover these deposits, are fixed and cannot be located elsewhere.

In direct response to stakeholder consultation, MRL has made several key changes to site design and layout optimisation since referral of the Proposal:

- The J5 WRL was initially a single WRL located further east than the current design. The eastern end of the WRL encroached upon a large drainage line and potentially could have impeded water flow following large rainfall events. The WRL was split into two separate WRLs, one either side of the main access road to the mine. This allowed the eastern WRL to be reduced in size so that it no longer encroached upon the drainage line. The western WRL was also redesigned to avoid populations of conservation significant flora.
- The Bungalbin East WRL was initially located immediately adjacent to the mine pit to reduce the waste haulage distance and therefore increase mine profitability. It has subsequently been repositioned further from the pit to minimise impacts on the landform, in this case the Helena-Aurora Range, as well as dense populations of conservation significant flora.
- The overall land disturbance area of the WRL at Bungalbin East has been decreased significantly from 176 ha to 98 ha. This is a result of rescheduling the mine plan to focus on the southern half of the Bungalbin pit early in the mine life to create a void for backfilling. Waste material from the northern half of the Bungalbin pit will then be hauled a shorter distance to backfill the void. This not only reduces the area and height of the waste dump, and hence the environmental impact, but also reduces the number of trucks required, improving the economics of the Proposal. MRL has successfully applied this strategy at Carina (also in the Yilgarn) and will also implement this strategy at Iron Valley in the Pilbara. This opportunity is

unlikely to be available at J5 where the vertical dip of the orebody means that backfilling would sterilise potential pit cutbacks (within the area proposed under this PER). Backfilling of all the waste cannot be achieved without rehandling of the entire waste rock volume after the extraction of all of the ore, an undertaking that would have an unsustainable negative impact on the economics of the proposal disproportionate to any environmental benefits of doing so.

- The area of disturbance comprising the mine pit at Bungalbin East was reduced to avoid a population of *L. bungalbin (*Priority 1*).*
- The elevation profile of all WRLs was revised from a traditional berm and batter arrangement to a single concave slope. At Bungalbin East, the shape of the WRL was also elongated from its initial circular shape. These changes are expected to provide a better aesthetic form that, coupled with appropriate landscape treatment post mining, will better blend with the surrounding topography.
- The extent of supporting infrastructure was decreased at both J5 and Bungalbin East by resizing the ROM pads and removing the evaporation ponds (as these ponds are not required as mining will occur above the groundwater table).
- The supporting infrastructure area at Bungalbin East was repositioned further west, which allowed the WRL at Bungalbin East to also be repositioned further to the southwest. Access roads between the pit and the WRL at Bungalbin East were re-designed to avoid populations of the threatened flora species *Tetratheca aphylla* subsp. *aphylla*.
- The mid-section of the J5 haul road was realigned further south to avoid a portion of a major drainage line with the same alignment i.e. the haul road was positioned within and parallel to the drainage line. Miscellaneous Licence L77/270 was applied for specifically for this reason.

Overall, these changes have reduced the total area of direct disturbance (clearing) for the Proposal from 720 ha as referred to 611 ha as proposed. This includes a net reduction in the mine pit area at Bungalbin East from 149 ha to 147 ha.

2.7 Approach to environmental management

A key principle of EIA in WA is the use of best practicable measures and genuine evaluation of options or alternatives in locating, planning and designing proposals to mitigate detrimental environmental impacts and to facilitate positive environmental outcomes and a continuous improvement approach to environmental management (Government of Western Australia, 2012).

Best practicable measures are discussed below in the context of environmental management. Importantly, the achievement of best practices is greatly facilitated where proponents have an environmental management system in place, particularly if it is consistent with an international standard such as ISO 14001 (Environmental Protection Authority, 2003).

To manage its impacts on the environment, MRL adopts a systematic management approach based on the international standard for environmental management systems (International Organisation for Standardisation, 2015). MRL's Environment and Community Policy 2016 is the cornerstone of this approach, a copy of which is contained in **Appendix 1-A**.

The policy promotes sustainable environmental and community practices with a stated objective of no harm to the environment or adverse impacts on the communities within which MRL operates, beyond that which is necessary to conduct its business and is approved by Government. It commits to developing and implementing management systems that enable the company to conduct its business in a responsible and appropriate manner.

From this policy, MRL has developed a corporate Environmental Management Plan (EMP) to provide an overview of MRL's approach (**Appendix 2-A**). The EMP forms an important component of MRL's Environmental Management System as it outlines the Plan-Do-Check-Act (PDCA) model and how it applies at MRL. This model is a feature of the ISO 14001:2015 standard and has leadership as a central attribute. The PDCA model, as it applies to MRL, is described in **Table 2-4**.

Routine policies and procedures developed at the corporate level will apply to the Proposal as well as Proposal-specific plans and procedures included with this PER or to be developed in the future e.g. in response to conditions of approval.

Recognising the need to achieve best practice environmental management in relation to the Proposal, MRL is committed to certifying the EMS for the Proposal to the ISO 14001 standard within two years after commencing productive mining operations.

TABLE 2-4: EMS MODEL COMPONENTS AND ACTIONS

Component	Actions
Leadership	• Take accountability for effectiveness of EMS. • Integrate EMS into MRL's business processes. • Ensure the resources needed for the EMS are available. • Promote continual improvement.
Plan	• Establish environmental objectives, KPIs and processes necessary to deliver results in accordance with MRL's policy. • Identify legal obligations.
Do	• Develop and implement an EMP. • Develop and implement systems and operational procedures, and work instructions. • Identify and meet training needs. • Identify responsibilities and accountabilities. • Emergency preparedness and response.
Check	• Measure progress against KPIs. • Environmental monitoring programs. • Auditing and inspection. • Records control.
Act	• Consider performance and take actions to continually improve.

3. ENVIRONMENTAL SETTING

This section provides an overview of the existing environment in a local and regional context from a holistic perspective. In doing so it provides an understanding of the broad environmental setting, within which the Proposal will be implemented, in terms of its condition, biodiversity and ecosystem processes. Detailed information on the existing environment is provided for each preliminary key environmental factor in **Section 5** to **Section 11**.

3.1 Environmental condition

The Proposal is situated within a predominantly natural setting, consistent with its location in a semi-remote area of WA some 100 km north of the nearest permanent settlement at Southern Cross (population 762). The Mt Manning area has experienced relatively low levels of human disturbance when compared to other parts of the broader Avon-Wheatbelt region.

Aboriginal uses of the land by the Kaparn and Kelamaia Kabu(d)n peoples are evident through the archaeological and ethnographic investigations discussed fully in **Section 11**.

Early European land uses such as timber-cutting and pastoralism have gradually made way for more modern uses like conservation and recreation, as evidenced in recent times by the retirement of pastoral leases coupled with proposals for additional conservation/nature reserves.

Mineral exploration and mining (mostly gold and iron ore) has occurred in the region since the discovery of gold near Southern Cross and iron ore at Koolyanobbing, both in 1887.

At the local scale, it is estimated that about 16 ha of the HAR has been disturbed as result of previous human use (**Figure 3-1**). When the plains surrounding the HAR are included the area of disturbance increases to 151 ha (**Appendix 6-A**).

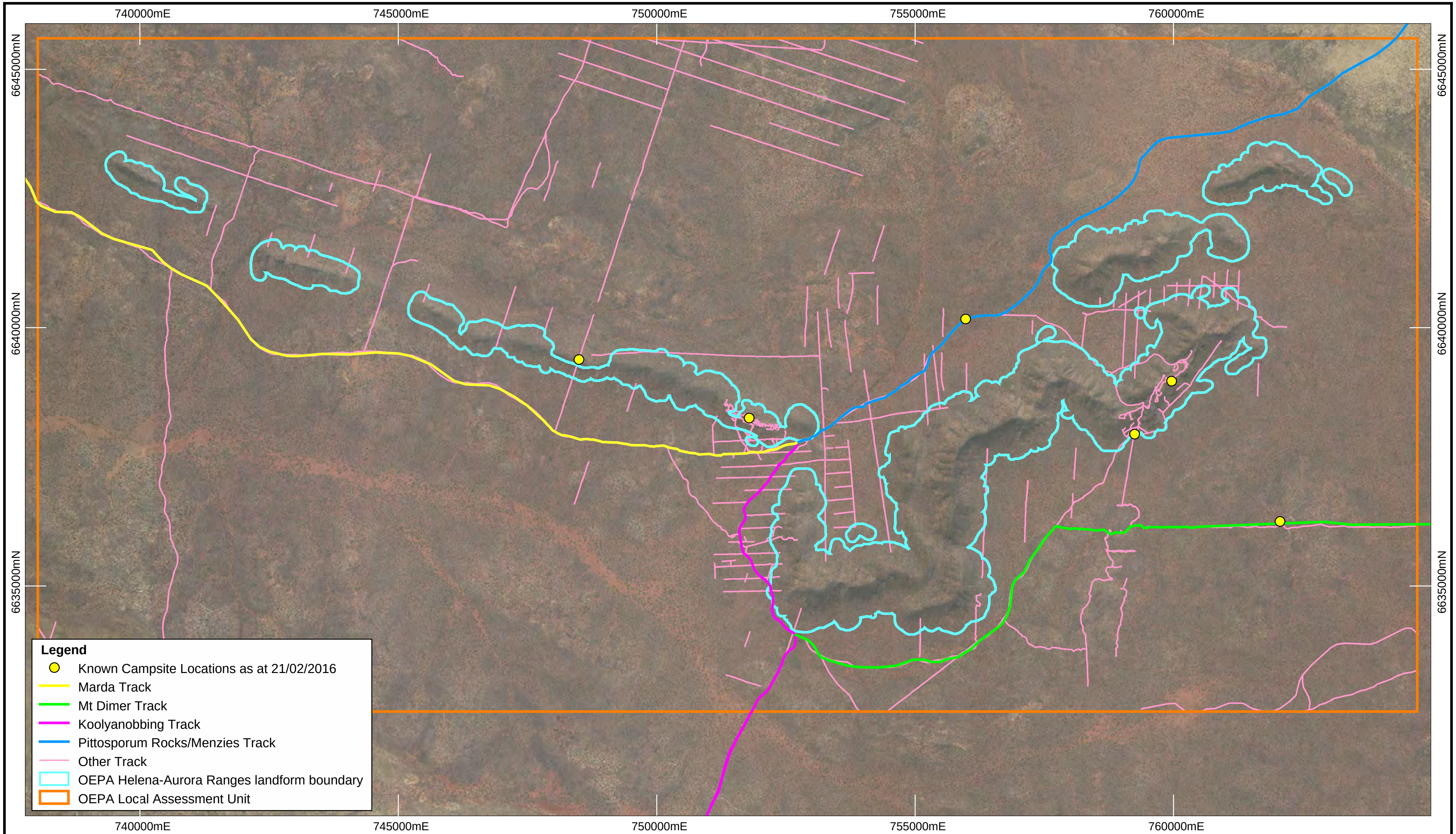
Disturbance of the HAR and the surrounding area is predominantly comprised of former access tracks, drill pads, sumps and trenches (costeans) for mineral exploration. Many of these tracks are no longer in use, and have become increasingly impassable due to regrowth of native vegetation as well as fallen timber.

Access tracks and other open areas are now predominantly used by visitors for recreation purposes, including the exploration tracks and drill pads that were first constructed by BHP on the HAR. Recreational use of the area is largely unmanaged, which reflects the low level of visitation and therefore an absence of the need for active management. Nonetheless, recreation activities such as camping and four-wheel driving continue to have an impact on the environment, primarily as a result of poor waste disposal practices and unmanaged vehicle access.

3.2 Biodiversity

Biodiversity is the variety of all life forms on earth – the different plants, animals and micro-organisms and the ecosystems of which they are a part. Much of the popular focus on biodiversity relates to species diversity, but genetic diversity and ecosystem diversity are also important elements of biodiversity as a whole.

Southwest WA harbours a rich and endemic flora with a substantial number of naturally rare species having highly isolated and fragmented populations (Hopper, et al., 1996; Hopper & Gioia, 2004).



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: Landgate (2012)

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EXISTING DISTURBANCE

Figure: **3-1**

Much of this species richness and endemism occurs within the South-western Australian Floristic Region (SWAFR), the boundary of which occurs at the 300 millimetres (mm) rainfall isohyet that marks the transition to the more arid interior (Gibson, et al., 2010).

BIF ranges are a series of ironstone ranges that extend inland from the boundary of the SWAFR for over 750 km. The plants and vegetation associated with these ranges are distinct from the surrounding landscape and are strongly correlated with elevation (Beard, 1981; Gibson, 2004; Gibson, et al., 2012).

Early flora studies of BIF ranges reported significant changeover of flora species between ranges, despite these ranges having similarities in species richness and composition (Gibson & Lyons, 2001) and in some cases similar local underlying ecological gradients combined (Gibson & Lyons, 1998a; 1998b). The cause of this changeover was initially thought to be partly in response to regional climatic gradients (Gibson & Lyons, 1998a).

In more recent times, the (biodiversity) conservation significance of BIF ranges is understood to arise in response to the ranges being repositories of plant taxa endemic to, or with distributions centred on, these landforms (Butcher, et al., 2007a; Gibson, et al., 2007; 2010; 2012). It is thought that the landforms may have acted as refugia for such taxa during drier climatic cycles (Keppel, et al., 2012), as well as centres of more recent speciation (Butcher, et al., 2007a).

3.2.1 Biodiversity hotspots

At a global scale southwest WA is recognised as being rich in plant species, being one of 34 global biodiversity hotspots.

Global biodiversity hotspots are places where levels of biodiversity are exceptionally high in conjunction with loss of previous habitat as well as ongoing threats to biodiversity (State of the Environment Committee, 2011). To qualify as a global biodiversity hotspot an area must have: (a) at least 1,500 vascular plants that do not occur anywhere else on the planet; and (b) 30% or less of its original (remnant) natural vegetation (Conservation International, 2016).

The Australian Government, through the Threatened Species Scientific Committee, has identified 15 national biodiversity hotspots. Input was sought from biodiversity experts, conservation groups, museums and the states and territories during the process of identification. Eight of the 15 national biodiversity hotspots in Australia are located in Western Australia.

Many of Australia’s national biodiversity hotspots are located in areas of substantial resource development, most notably agriculture. At this time BIF ranges, such as the HAR, are not a nationally recognised biodiversity hotspot. The nearest national biodiversity hotspot to the Proposal is the ‘Central and Eastern Avon Wheatbelt’ hotspot. This hotspot lies to the west of the Proposal and is characterised by:

- woodlands of Wandoo, York Gum, Salmon Gum, Casuarina and some areas of proteaceous scrub heaths
- many of WA’s threatened plants and birds - particularly plants including grevilleas, hakeas, eucalypts, acacias, eriostemons and the asteracea family – as well as invertebrate fauna such as ground-dwelling spiders
- extensive clearing for agriculture and grazing, leading to widespread elevated salinity levels as well as loss or degradation of remnant vegetation, wetlands, river systems and plant and animal populations.

Within the published scientific literature on BIF ranges, there is recognition of two centres for endemic and BIF specialist taxa (otherwise called hotspots), with one of these hotspots being centred on the HAR (Gibson, et al., 2012). These hotspots broadly coincide with the transitional area between the species-rich SWAFR and the more arid interior.

The number of restricted endemic taxa occurring on BIF ranges in this transitional area (e.g. Die Hardy, Windarling, Mt Jackson and Helena-Aurora ranges) is considerably lower than is found on other ranges in higher rainfall areas of the SWAFR (e.g. Stirling Range, Ravensthorpe Range), but substantially higher than was found in a survey of 24 BIF ranges across the semi-arid region of WA (Gibson, et al., 2010; 2012).

In discussing the implications of their findings for conservation, Gibson et al (2012) note that:

- a comprehensive reserve network would require inclusion of part of all the ranges in the formal conservation reserve system
- there are no clear priorities for reservation since vegetation on each range is unique
- the highest priority areas for conservation would be the two identified concentrations of the ironstone specialists [one of which is the HAR], with a second tier made up of those ranges supporting ironstone species not occurring in the hotspot areas
- most of the existing and proposed mines occur within the identified hotspots and that conserving these unique ecosystems will present considerable challenges.

Despite the challenges of balancing conservation with development in biologically diverse areas, development need not be precluded from occurring within biodiversity hotspots. At the national level, for example, 2,300 square kilometres of clearing was approved within the Hamersley-Pilbara biodiversity hotspot under the EP Act to 31 December 2013. Proposed further clearing of over half that amount again has been subject to formal assessment since that time (Environmental Protection Authority, 2014a). The Hamersley-Pilbara biodiversity hotspot is an example of the ability of biodiversity and development to co-exist. Similarly, co-existence between biodiversity and development should be able to be achieved in the HAR.

3.3 Key ecosystem processes

An ecological system, or ecosystem, describes living organisms, the climate, soil, water and air they live in and the interactions of these organisms with each other and their surrounding environment. Ecosystems may be characterised in terms of their structure, composition and processes (United States Department of Agriculture, 2013). This section focusses on the ecosystem processes occurring in the Mt Manning area, but in doing so it inevitably touches on ecosystem structure and composition.

Ecosystem processes refer to the life cycles of organisms, the changes in environment and the interactions between them. While ecosystems may differ dramatically in terms of their structure and composition, they all share the same fundamental processes - input, production, storage, recycling and output - although these processes are carried out by different species in each ecosystem (United States Department of Agriculture, 2013). The study of such processes is known as ecology.

A broad framework that can be applied to understand the ecology of the Mt Manning area, including the BIF ranges, is provided by Morton et al (2011), who present a series of propositions regarding the ecology of Australia’s arid zone. In this context the arid zone includes arid areas such as Australia’s deserts and semi-arid areas such as the Mt Manning area.

Morton et al (2011) argue that most features of arid Australia can be explained in terms of two dominant physical and climatic elements: rainfall variability, leading to extended droughts and occasional flooding rains; and widespread nutrient poverty. The responses to these drivers of the ecosystem may be summarised as:

- a distinctive spectrum of life histories of plants that strongly reflect temporal patterns of soil moisture

- low levels of phosphorous (together with abundant soil moisture occasionally) favouring plants that produce a relative excess of carbohydrate that, in turn, leads to:
  - fire prone ecosystems
  - assemblages dominated by consumers of sap and other carbohydrate products
  - abundant detritivores (particularly termites).
- fluctuations in production due to variable rainfall providing opening for consumers (fauna) with opportunistic life-histories (including inhabitants of ephemeral rivers and lakes)
- consumer species exhibiting some dietary flexibility or utilising more dependable resources, giving rise to greater stability in species dynamics and composition of assemblages than might be expected under a variable rainfall regime
- the long-standing influence of humans (e.g. Aboriginals) as they accessed resources.

An application of Morton et al's (2011) framework to the Mt Manning area is provided in **Table 3-1** in terms of the physical environment, plant and animal life and human interactions.

TABLE 3-1: ARID ZONE ECOLOGY AND FRAMEWORK FOR THE MT MANNING AREA

Proposition	Typical characteristics	Mt Manning area
Physical environment		
1. Rainfall is especially unpredictable in Australia's arid zone	• Long periods of aridity interrupted by occasional heavy rains although overall the area is dominated by cool season rainfall (winter rains).	• Average annual rainfall is 327 mm, the majority of which occurs during winter. • There is high inter-annual variability of rainfall e.g. as high as 646 mm in 1999 and as low as 210 mm in 2010.
2. Big rains structure ecosystems	• Large rainfall events driven in sequences by El Niño-Southern Oscillation (ENSO) and similar effects. • Heavy rainfall stimulates episodic recruitment in Australian desert perennial plants and affect temporal patterns of soil moisture.	• Occasional large rainfall events also occur during summer months (e.g. January 2016), often associated with residual cyclonic activity, the frequency of which is affected by ENSO. • The surface of the HAR is a mixture of goethite and haematite-weathered BIF, covered in part by a laterite derived from the underlying weathered BIF. The more siliceous parts of the BIF have not weathered and these account for the steep flanks of the range as well as the main ridge lines. • Where there has been structural weakness, the BIF has been altered to massive goethite with some haematite, with the main concentrations occurring at J5 and Bungalbin East. • Some plants flower opportunistically, typically after episodic rainfall i.e. not only during spring.
3. An infertile well-sorted landscape	• Soils are derived from highly weathered parent materials, are well sorted and poor in macro-nutrients such as Phosphorous and Nitrogen as well as micro nutrients such as iodine, cobalt and selenium. The latter are important to the	• Soils are well sorted by erosion and deposition depending on distance from the ridge crest: ○ Erosion of friable weathered surface gravels on the ridges has left a thin layer of gravel over ironstone.

Proposition	Typical characteristics	Mt Manning area
	metabolism of mammals and are not typically found in plants of the arid zone.	○ The thickness of surface gravels increases further down-slope due to colluvial deposition. ○ Fine-textured alluvial soils surround the ridges as the majority of coarse particles (gravels) have been deposited further upslope. • Soils are nutrient poor with low levels of mineralised Nitrogen and Phosphorous. • Absence of large mammals – only small carnivorous, omnivorous or herbivorous mammals e.g. dunnarts, mice, pygmy possums and bats.
Plant life in arid Australia		
4. Soil moisture shapes the spectrum of plant life history strategies	• Soil moisture defines the opportunities for plant life-histories on different substrates – arid areas are pulse-reserve ecosystems that provide intermittent opportunities for plant growth. • Germination and establishment are possible only during periods of high soil moisture. • The duration of low-moisture periods, especially the predictability of duration, is decisive for persistence strategies. • Soil fertility, fire and herbivory interact with soil moisture to shape the spectrum of life-histories in significant ways.	• Skeletal soils on the ridge tops are deficient in moisture with very low plant-available water. Plants without the ability to penetrate fractures in the ironstone, to source moisture from underlying clays, have adapted to prevent water loss and minimise transpiration: ○ e.g. *Leucopogon spectabilis* and *Tetratheca aphylla* subsp. *aphylla*, which can be found growing from small cracks/crevices in vertical rock with virtually no soil. • Soils on the lower-mid slopes of the ridges have moderate water holding capacity and mark a transition in plant composition and structure – *Eucalypt* and *Acacia* species become more dominant:

Proposition	Typical characteristics	Mt Manning area
		○ The lateritic hardcap beneath these soils prevents underlying weathered clays from drying out. Thus, there is appreciable soil moisture directly below this layer. Some plants can access this moisture, which is annually recharged, to support their transpiration requirements. • Deep alluvial clays with higher water holding capacity are found throughout the plains surrounding the ridges. In proximity to the ridges these soils support a non-chenopod shrubland with or without a eucalypt woodland overstorey, usually with *Austrostipa* spp. Further out from the ranges, the shrubland becomes dominated by chenopods.
5. Fertility controls digestibility	• Low nutrient soils favour longer leaf life spans – foliage tends to be less digestible to herbivores in infertile environments. • In Australian deserts there are virtually no annually drought-deciduous species, which results from infertility as well as from patterns of soil moisture. • Indigestibility of perennial plant foliage is likely to be of most prominence in vegetation formations growing on the poorest soils such as mulga shrublands and semi-arid woodlands.	• No drought-deciduous plants i.e. plants that drop their leaves during the 'dry' season or periods of drought. • Absence of large herbivores reflects a lack of readily digestible plant-based food for such animals. • Vertebrate fauna assemblage dominated by small carnivorous or omnivorous species in response to available food sources.
6. Carbohydrate is plentiful	• Nutrients, particularly phosphorous, are relatively expensive for plants to obtain and retain than carbohydrate on poorer soils in arid environments. • Plants growing in infertile soils can photosynthesise rapidly when moisture is available due to evergreen and long-lived leaves, thereby	• Semi-arid *Eucalyptus* woodland has total biomass of 55,000 kg per hectare (Stafford-Smith and Morton, 1990). This broad vegetation type is found throughout the area. • The yellow sandplains dominated by *Acacia* spp. are also expected to have relatively high levels of

Proposition	Typical characteristics	Mt Manning area
	producing carbohydrate cheaply per unit phosphorous and enabling investment in carbohydrate rich tissues and compounds with little reduction in growth potential. • Plants use woody anti-herbivore defences; tolerate high levels of sap herbivory, produce arils, extra-flora nectaries and fleshy fruits and achieve unexpectedly high levels of biomass.	biomass.
7. Fire is a powerful influence	• Fire is of particular influence in arid ecosystems due to high perennial biomasses, slow rates of decomposition and plentiful carbohydrate-based tissues. • In low-intensity regimes, fire acts as a circuit breaker by unlocking nutrients tied up with abundant carbohydrate and plays a role in maintaining plant species diversity. • Fire is most frequent in northern Australian deserts due to higher rainfall and the presence of perennial grasslands. In Acacia shrubland and semi-arid woodland, fire is dependent on accrual of fuel from short-lived grasses and can occur only after exceptional rainfall sequences. • With sufficient grass cover following high rainfall, chenopod shrubland can burn, inducing long-lived changes because the dominant perennials are fire-sensitive.	• Morton et al (2011) report a return interval of fire within *Acacia* shrubland of 30-100 years and within semi-arid woodland of 20-100 years. • The majority of the Mt Manning area has not been recently burnt, with 62% of all botanical survey quadrats showing no evidence of fire. Some (36%) quadrats showed evidence of fire from more than 5 years ago with the remainder (2%) being burnt between 2 and 5 years ago. • There is an absence of perennial grassland in the area, such as that typically found in arid areas in northern Australia, which reflects the relatively long average return time of fire despite the *Eucalyptus* woodland and *Acacia* shrubland on yellow sandplains containing high levels of biomass.

Proposition	Typical characteristics	Mt Manning area
Consumers in arid Australia		
8. On poorer soils herbivorous and detritivorous consumers are constrained by both indigestibility and irregularity of production	• Herbivores in areas of infertile soils must use poorly digestible or very intermittent plant production, leading to either: • opportunistic presence tied to ephemeral availability of a high quality resource; or • persistent and specialised use of perennial plants. • Large amounts of indigestible biomass develop with intermittent rainfall in infertile ecosystems and therefore a large proportion of production goes directly into a detritivorous pathway that appears to be dominated by termites.	• See 9.
9. On more fertile soils herbivorous and detritivorous consumers are constrained principally by irregularity of production	• Herbivores exhibit a spectrum of life history responses from opportunistic presence cued to ephemeral availability of plant resources through persistent, specialised use of perennial plants. • The detritivorous pathway is dominated by a variety of consumers rather than by termites. • Nutrient constraints in chenopod shrubland, drainage systems and semi-arid woodland are relatively mild.	• Despite having relatively poor soils, the HAR is richer than, for example, the sandy desert areas further inland. • Perhaps less evident in semi-arid areas in relation to vertebrate fauna as these species are usually able to exploit a wider range of habitats. However, it is perhaps more evident in the SREs, which are more confined to particular habitats.
10. Consumer of plant exudates are prominent	• Ants are major consumers of arils, flora and extrafloral nectar, exudate (e.g. sap, gums, resin etc) and excretory products of sap-sucking insects. • Hemiptera (bugs such as cicadas, tree hoppers and mealybugs) are abundant on *Eucalyptus*, *Acacia* and other perennial plants. • Birds are major consumers of nectar and other	• The most abundant bird family recorded by ecologia (2016) was the honeyeaters (Meliphagidae), with 13 species.

Proposition	Typical characteristics	Mt Manning area
	carbohydrate-rich products e.g. the diverse and abundant honeyeaters and chats (Meliphagidae) occur as both residents and nomads in most ecosystems.	
11. Assemblages of higher order consumers reflect infertility and irregularity of production	• The composition of assemblages of higher-order consumers is governed by the mixture of primary consumers, ultimately reflecting patters of water and nutrient availability. • In less fertile landscapes, reptiles and invertebrate predators are dominant. • Mammals are usually uncommon, either as a result of the impact of ecological changes since European settlement or, independently, of the relative paucity of herbivores, in particular seed-eating rodents.	• Mammals are less common than birds, reptiles and invertebrate fauna species.
12. Some consumers exhibit dramatic opportunism in response to irregularity of production	• Pronounced variability of rainfall has led to prominence of species able to take advantage of peaks in production and for tiding over the inevitable troughs. • Especially evident in large-scale temporary aquatic ecosystems.	• No evidence of any particular species able to take advantage of peaks in production. • No large-scale temporary ecosystems such as wetlands.
13. Consume assemblages display underpinning stability within their dynamism	• Despite the uncertain climate of arid Australia, many animals that are functionally important do not fluctuate in a straightforward way with rainfall because of various forms of buffering. • Many plants succeed as perennials by tapping into sources of water stored following sizeable rainfalls (Proposition 2).	• No evidence.

Proposition	Typical characteristics	Mt Manning area
Human interactions		
14. Long-standing feedbacks between humans and environmental structure and function	• Aboriginal people influenced environmental structure and composition as a result of efforts to enhance production or, at least, stabilise access to their natural resource requirements. • Role of human-induced fire in chenopod shrublands and drainage systems is less certain than systems dominated by grasslands.	• Aboriginal people may have burnt Acacia shrubland on granite sandplains; but less likely the Eucalyptus woodlands. • Access to water was of key importance with sources including gnamma holes, water trees and modification of drainage lines to enhance water supply.

4. ENVIRONMENTAL IMPACT ASSESSMENT FRAMEWORK

4.1 Environmental Impact Assessment in Western Australia

The overall framework for EIA in WA is described in the EPA (2015a) *Environmental Assessment Guideline for Application of a significance framework in the environmental impact assessment process – Focussing on the key environmental factors*.

The EPA determines the form, content, timing and procedure for the environmental review of a proposal. For proposals assessed at the level of PER, such as this Proposal, the EPA undertakes this task through the endorsement of an ESD.

The outcome of EIA is a decision by the EPA on the likely significance of impacts of a proposal, using a risk based approach. The steps through which this outcome is reached and the relationship between the EIA process and relevant guidance material is shown in **Figure 4-1** (the current step in the process is highlighted).

EIA Process Step	Pre-referral stage	Referral and EPA decision on whether to assess a proposal	Setting the level of assessment	Scoping of further work required	Preparation of environmental review documents	EPA assessment and determination of key environmental factors	EPA report and recommendation on acceptability of proposal and conditions
Guidance materials on the EIA process	Application of a significance framework in the EIA process - EAG 9						
	Assessment on Proponent Information (category A) - EAG 14	Defining the key characteristics of a proposal - EAG 1 Referral of a proposal under s38of the EP Act - EAG 16		Scoping a proposal - EAG 10	Assessment on Proponent Information (category A) - EAG 14		Approach to recommending environmental conditions - EAG 11
Guidance materials on environmental factors	Environmental factors and objectives - EAG 8						
	Supported by specific guidance on many of the environmental factors, available on the EPA's website						

FIGURE 4-1: RELATIONSHIP BETWEEN EIA PROCESS AND GUIDANCE

The EPA publishes specific guidance at various levels of detail in relation to environmental factors. This guidance generally takes the form of:

- Position Statements (e.g. PS 2 Environmental Protection of Native Vegetation in WA).
- Environmental Protection Bulletins (e.g. EPB 23 Landforms).
- Guidance Statements (e.g. GS 56 Terrestrial Fauna Surveys for EIA in WA).
- Environmental Assessment Guidelines (e.g. EAG 13 Consideration of Environmental Impacts from Noise).

Relevant specific guidance is addressed in the assessment chapters of the PER for the preliminary key environmental factors.

4.1.1 Environmental factors

An environmental factor is a part of the environment that may be impacted by an aspect of a proposal (Environmental Protection Authority, 2015a).

At the scoping and environmental review stages of the EIA process the key environmental factors are described as "preliminary" key environmental factors. These are the environmental factors initially identified based on referral information and subsequent consultation with DMAs and the proponent (Environmental Protection Authority, 2015b).

The scoping stage is the point in the process when the preliminary key factors are finalised and it is these factors that must be addressed in the environmental review documentation.

The preliminary key environmental factors for the Proposal, as set out in the ESD, are:

- Flora and Vegetation
- Landforms
- Amenity
- Subterranean Fauna
- Terrestrial Fauna
- Hydrological Processes and Inland Waters Environmental Quality
- Amenity
- Heritage
- Offsets (Integrating Factor)
- Rehabilitation and decommissioning (Integrating Factor).

Key environmental factors are those factors where the EPA's objectives may be met but where there is a (current) lack of confidence, signifying the need for more information or conditions related to implementation (including, if necessary, offsets).

For the EPA to recommend that the Proposal be implemented, it needs to be confident that all key environmental factors can be managed to meet the associated environmental objectives.

It should be noted that not all preliminary key environmental factors transition to key environmental factors. Some factors may be removed from further assessment where the EPA considers that information provided through the assessment process is sufficient to demonstrate that the proposal is no longer likely to have a significant effect on that factor.

4.1.2 EPA significance test

The EPA applies a Significance Framework to make decisions through the EIA process, based on the concept of significance established under the EP Act. The basic form of the significance framework is shown in **Figure 4-2**.

The basis for the EPA's determination of the likely significance (i.e. the significance test) and acceptability of a proposal is whether or not it is consistent with the framework of environmental principles and policies, environmental factors and associated objectives and relevant guidance material.

With regard to environmental objectives, the axis on the left of **Figure 4-2** shows increasing 'likely significance' and there are two threshold levels with respect to the EPA's objectives:

- The level at which there is likely to be a significant effect on the environment as referred to in the EP Act.
- The level at which there is likely to be an unacceptable effect on the environment.

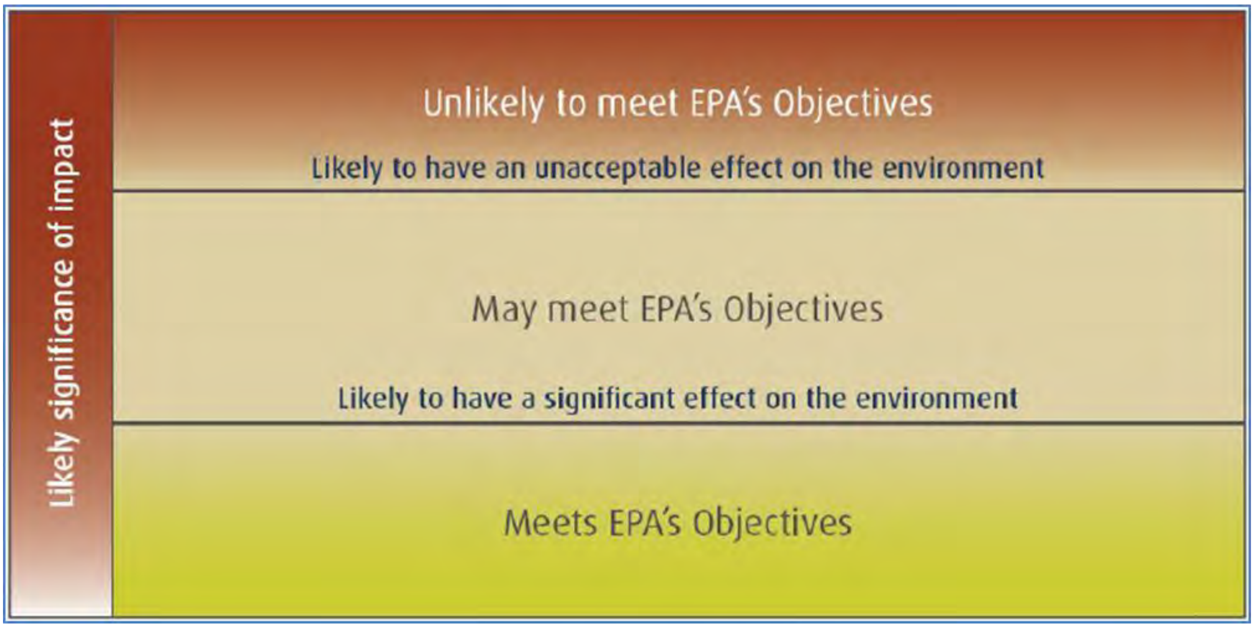


FIGURE 4-2: EPA SIGNIFICANCE FRAMEWORK (EPA, 2015A)

In the event that a Proposal is likely to have an unacceptable or significant effect on the environment, a hierarchy of actions is applied to mitigate such effects:

- Avoid – measures taken to avoid the impact altogether.
- Minimise – measures taken to reduce the duration, intensity or extent of impact.
- Rehabilitate – measures taken to repair, rehabilitate or restore disturbed areas.
- Offset – measures taken to counter-balance/compensate for significant residual impacts.

Relevant matters for consideration as part of the significance test are set out in the *Environmental Impact Assessment Administrative Procedures 2012* and include:

- values, sensitivity and quality of the environment that is likely to be impacted
- extent (intensity, duration, magnitude and geographic disturbance area) of the likely impacts
- consequence of the likely impacts (or change)
- resilience of the environment to cope with the impacts or change
- cumulative impact with other projects
- level of confidence in the prediction of impacts and the success of proposed mitigation
- objectives of the EP Act, policies, guidelines, procedures and standards against which a proposal can be assessed
- presence of a strategic planning policy framework
- presence of other statutory decision-making processes that regulate the mitigation of the potential effects on the environment to meet the EPA's objectives and principles for EIA
- public concern about the likely effect of the proposal, if implemented, on the environment.

With regard to the latter, the key stakeholders are identified and an outline of the consultation conducted to date is provided in Section 1.6.

In making decisions on significance, the EPA also considers whether a proposal is consistent with:

- the principles of the EP Act
- additional principles adopted by the EPA
- international, national and state policy agreements related to the environment.

4.2 Australian Government Environmental Impact Assessment Requirements

Under the EPBC Act actions that have, or are likely to have, a significant impact on a matter of national environmental significance, require approval from the Australian Government Minister for the Environment and Energy. These actions are known as controlled actions.

Matters of national environmental significance protected under the EPBC Act are:

- world heritage properties
- national heritage places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species and ecological communities
- migratory species (protected under international agreements)
- commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mines)
- a water resource, in relation to coal seam gas development and large coal mining development.

A significant impact is defined as “an impact which is important, notable, or of consequence, having regard to its context or intensity.” More specifically, the significance of an impact depends upon the sensitivity, value and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of the Environment, 2013).

The significance of an impact on a matter of national environmental significance can be assessed using the ‘significant impact criteria’ developed for each matter (Department of the Environment, 2013). For listed threatened species and ecological communities, the criteria vary depending on the listing category (e.g. critically endangered, endangered, vulnerable) and are provided in **Table 4-1**.

The extent to which an action is deemed to have a significant impact on a matter of national environmental significance takes into account proposed feasible alternatives to the action, possible mitigation measures and proposed offsets to address residual significant impacts on such matters.

4.3 Assessment of environmental impact

This document presents the outcomes of work undertaken in accordance with the ESD. It aims to show how the Proposal could be designed and implemented to meet the requirements of both the Australian Government Department of the Environment and Energy (DEE) and the WA EPA through application of the mitigation hierarchy.

TABLE 4-1: SIGNIFICANT IMPACT CRITERIA (EPBC ACT)

Critically endangered and endangered	Vulnerable
An action is likely to have a significant impact if there is a real chance or possibility that it will:	
• lead to a long-term decrease in the size of a population	• lead to a long-term decrease in the size of an important population of a species
• reduce the area of occupancy of the species	• reduce the area of occupancy of an important population
• fragment an existing population into two or more populations	• fragment an existing important population into two or more populations
• adversely affect habitat critical to the survival of a species	
• disrupt the breeding cycle of a population	• disrupt the breeding cycle of an important population
• modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	
• result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	• result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
• introduce disease that may cause the species to decline, or	
• interfere with the recovery of the species	• interfere substantially with the recovery of the species

Discussion and evaluation with respect to preliminary key environmental factors and matters of national environmental significance addresses:

- the EPA's objective for the factor as well as Commonwealth and WA policies and guidelines that apply to the assessment of the potential impacts on the factor
- the existing environment and how the factor fits into the broader environmental/ ecological context
- the predicted extent and significance of impact on the factor/matter of national environmental significance arising from implementation of the Proposal
- the application of the mitigation hierarchy to reduce the significance of impacts in the context of the EPA's objective
- the residual significant impacts
- the predicted outcome, taking into account offsets, in terms of whether the Proposal is capable of meeting the EPA's objectives for each factor.

The PER also evaluates the extent to which the Proposal is consistent with the principles of the EP Act.

4.3.1 Cumulative impact assessment

The ESD requires consideration of impacts at a local and regional scale, including evaluation of cumulative impacts. There is no published guidance with respect to the assessment of cumulative impacts in WA for specific environmental factors. MRL has considered cumulative impacts to the extent reasonably practical to do so, and with particular reference to its Carina and J4 operations.

The cumulative impact of the Proposal on flora and vegetation, for example, has been assessed with respect to populations of conservation significant taxa. It assumes that the information on remaining populations of taxa includes plants removed by previous proposals by other proponents elsewhere in the region.

The assessment of cumulative impact at the vegetation community level is more difficult as community types identified by different botanical consultants are frequently not comparable, thereby limiting the extent of assessment.

MRL has sought to overcome this difficulty by engaging a single botanical consultant (ecologia Environment) to identify and map vegetation communities across its tenements in the Jackson, Helena-Aurora and Finnerty Ranges. This has allowed an assessment of the distribution of, and impact upon, vegetation communities at a regional scale.

5. FLORA AND VEGETATION

5.1 EPA objective, policies and guidelines

The EPA's objective for flora and vegetation is:

- To maintain representation, diversity, viability and ecological function at the species, population and community level.

The policy and guidance documents listed in **Table 5-1** have been referenced as part of the field investigations and impact assessment for flora and vegetation. The PER is consistent with these documents.

TABLE 5-1: LEGISLATION, POLICIES AND GUIDELINES CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key aspects	Application
EPA Policy and Guidelines		
EPA (2000). Position Statement 2: Environmental Protection of Native Vegetation in Western Australia.	Outlines the EPA's view of land clearing and its impacts on biodiversity, both within agricultural areas and elsewhere. Requires that there is no extinction of plants or animals, or loss of association or community of plants or animals. Provides a threshold value for retention of vegetation.	The PER compares the clearing threshold identified in PS2 against the extent of proposed clearing (refer **Section 5.3.1**of the PER). The PER also demonstrates that there will be no loss of a plant taxon or community (refer **Section 5.5**of the PER).
EPA (2002). Position Statement 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection.	Outlines the overarching principles for environmental impact assessment of biodiversity, including survey requirements, demonstration that all reasonable measures to avoid impacts have been taken, demonstration of no unacceptable loss and the application of genetic studies in impact assessment. The EPA expects that all terrestrial biological surveys will be made publicly available.	The quality of information and scope of field surveys meets the standards, requirements and protocols as determined and published by the EPA and DPaW (refer **Appendix 5-A**, [Section 3]) and **Appendix 5-B**. Biological surveys provide sufficient information to address: • biodiversity value at the genetic (for particular taxa), species and ecosystem levels (refer **Appendix 5-D** and **Section 5.2.1**of the PER) • ecological functional value at the ecosystem level. The PER demonstrates that all reasonable measures have been undertaken to avoid impacts on biodiversity, and provides

Legislation, Policy and Guidelines	Key aspects	Application
		information to assess whether the impact will result in an unacceptable loss of biodiversity (refer **Section 5.4.2**).
EPA (2004). Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.	Provides the general standards and a common framework for terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia, the quality and quantity of information that should be derived from these surveys, and the consequent analysis, interpretation and reporting.	**Appendix 5-A** (Section 3) outlines the survey methodology in detail, including consultation with DPaW to ensure consistency with this guideline. **Section 5.2.1** of the PER summarises the methodology used in conjunction with (Department of Environment and Conservation, 2006).
EPA (2007). Report 1256: Advice on areas of the highest conservation value in the proposed extensions to Mount Manning Nature Reserve. Advice of the EPA to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986.	Presents Ministerial Advice requested from the EPA under Section 16(e) of the Environmental Protection Act, following approval of the expansion in iron ore mining by Portman Iron Ore Ltd at the Windarling and Jackson Ranges. For the purpose of this advice, the request to identify “areas which require protection from extractive industries” is interpreted to include mining specifically. The advice primarily concerns Mt Manning Range Nature Reserve and its extensions, also known as the Yilgarn Conservation Reserves. This advice identifies areas that should be protected from mining and the use of environmental offsets.	Not directly used in the assessment but highlights existing advice about conservation values in the Proposal area.
EPA (2015). Environmental Assessment Guideline (EAG 17) for Preparation of management plans under Part IV of the Environmental Protection Act 1986.	Provides guidance to proponents on the content of management plans under Part IV of the EP Act.	Used as a guideline for the preparation of the draft Conservation-Significant Species and Communities Management Plan (**Appendix 5-H**).

Legislation, Policy and Guidelines	Key aspects	Application
EPA Checklist for documents submitted for EIA on marine and terrestrial biodiversity.	Provides the basis for consultants and proponents to conduct initial in-house screening of the quality of their EIA documents. It defines the minimum standard for the fundamental elements of EIA documentation to be submitted to the EPA.	All relevant items completed in relation to flora and vegetation and provided to OEPA.
Non-EPA Policy and Guidelines		
DEC (2006). Recommended Interim Protocol for Flora Surveys of Banded Ironstone Formations of the Yilgarn Craton. Unpublished. Department of Environment and Conservation, Perth, Western Australia.	Outlines the survey methodology protocol recommended for proponents commissioning assessments of the floristic values associated with prospective areas of banded iron formation.	**Appendix 5-A** (Section 3) outlines the survey methodology in detail, including consultation with DPaW to ensure consistency with this guideline. **Section 5.2.1** of the PER summarises the methodology used in conjunction with (Environmental Protection Authority, 2004).
EPA/DPaW (2015). Technical Guide – Flora and Vegetation Surveys for EIA.	Provides guidelines to ensure adequate flora and vegetation data of an appropriate standard are obtained for EIA.	This guideline was released subsequent to the completion of the majority of flora surveys supporting this EIA (2012-2016). Draft versions of this guideline were available at the time that data were analysed and relevant content was considered in the preparation of the technical report accompanying this section.
Commonwealth Policy and Guidelines		
Threatened Species Scientific Committee (TSSC) (2008). Approved Conservation Advice for *Tetratheca aphylla* (Bungalbin Tetratheca).	Provides a description, distribution and habitat, threats, research priorities and priority actions for Bungalbin Tetratheca Listed threats include mining inappropriate fire regimes and roadworks.	It should be noted that the Advice refers to Bungalbin Tetratheca (*Tetratheca aphylla*) as being recorded from the HAR and further south at Newdegate. The southern population refers to the subspecies *Tetratheca aphylla* subsp. *megacarpa* whilst the HAR population refers to the subspecies *Tetratheca aphylla* subsp. *aphylla*. *T. aphylla* subsp. *megacarpa* is not considered in this PER. The information on distribution (10 populations) and plant numbers (900 mature) for *T. aphylla* subsp. *aphylla*

Legislation, Policy and Guidelines	Key aspects	Application
		is incorrect as a result of the extensive botanical surveys of the HAR undertaken since publication of the advice. The Advice notes that populations within the HAR are in an area proposed for iron ore mining exploration. However, more recent surveys demonstrate that the taxa are distributed across the entire range with a significantly larger number of plants. Research priorities and regional/local priority actions identified in the Advice were reviewed to assist proposed management measures to reduce impacts as well as development of proposed offsets (Refer **Section 13** of the PER).
TSSC (2010). Approved Conservation Advice for *Leucopogon spectabilis* (Ironstone Beard-heath).	Provides a description, distribution and habitat, threats, research priorities and priority actions for Ironstone Beard-heath.	The PER compares the known population at time of issue of the Advice with the post-survey population (refer to **Section 5.3** of the PER). The information on distribution (four populations) and plant numbers (900 mature) for Leucopogon spectabilis is based on surveys undertaken between 2002 and 2006. The results of extensive botanical surveys of the HAR undertaken since publication of the advice in 2010 are discussed. The Advice notes that mining and exploration activity as being the key threat to the species with exploration activities occurring in close proximity. More recent surveys demonstrate that the taxon is more widely distributed across the HAR than previously recorded, with a significantly larger number of plants.

5.2 Existing environment

5.2.1 Surveys, desktop analyses and complementary investigations

Surveys for this Proposal were conducted by ecologia Environment between 2012 and 2016. Ecologia Environment's full report is attached as **Appendix 5-A**.

The survey design was developed in accordance with the methodologies outlined in Recommended Interim Protocol for Flora Surveys of Banded Ironstone Formations (Department of Environment and Conservation, 2006) and EPA Guidance Statement 51 (Environmental Protection Authority, 2004), and the principles outlined in EPA (2002). The survey design aimed to meet:

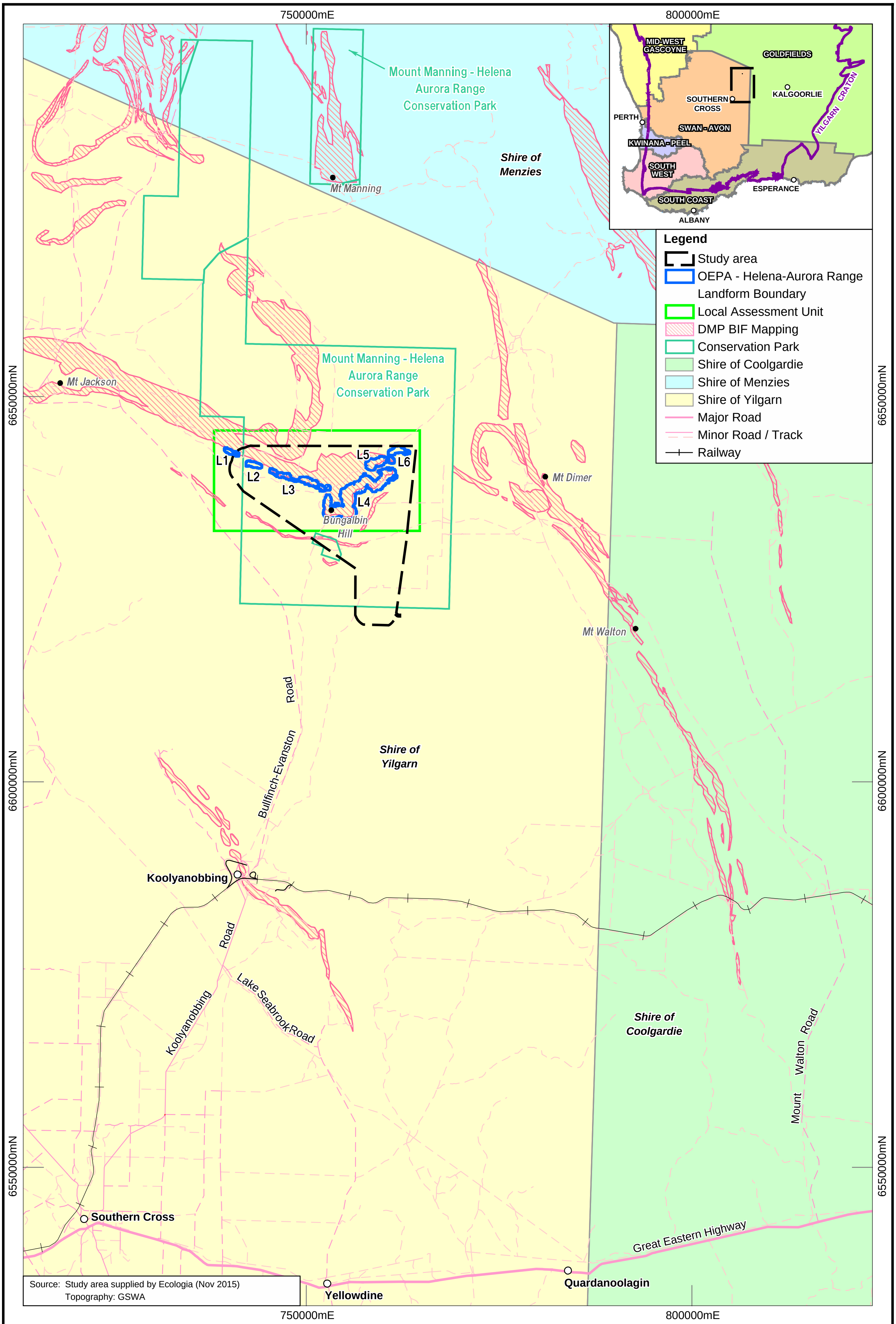
- the requirements for a Level 2 survey, as defined in Appendix 2 of Guidance Statement 51
- guidelines specific to flora surveys on banded ironstone formations (Department of Environment and Conservation, 2006)
- specific survey recommendations for particular species (Threatened Species Scientific Committee, 2008; 2010).

The study area covered almost all of the HAR and an area south of the HAR to include the proposed haul road (**Figure 5-1**). For the purposes of further discussion, the HAR is considered to be the landforms contained within the Local Assessment Unit (LAU) as advised by the Office of the OEPA (see **Figure 5-1**).

In total, 197 quadrats were established within the study area, almost all of which were assessed twice. Data obtained from quadrat surveys were supplemented by targeted searches for Threatened and Priority Flora. The overall survey effort is summarised in **Table 5-2**. Transects and quadrats forming the survey conducted for this Proposal are shown in **Figure 5-2**.

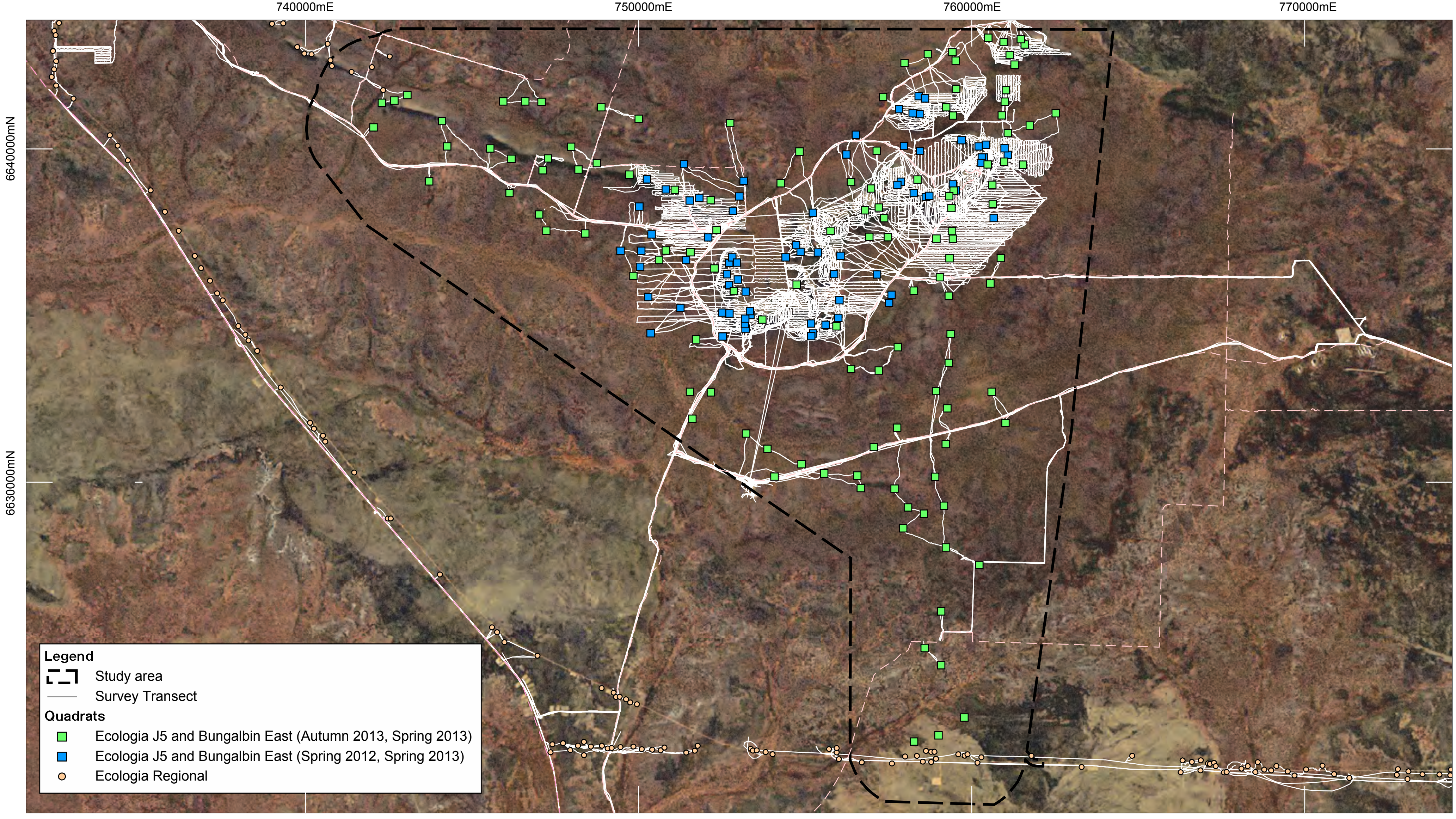
TABLE 5-2: FLORA AND VEGETATION - SURVEY EFFORT

Dates	Person days	Main activities
24-31 October 2012	32	Establishment of 74 quadrats plus incidental records and targeted searches for Threatened and Priority Flora.
15-22 May 2013	48	Establishment of an additional 123 quadrats plus incidental records and targeted searches for Threatened and Priority Flora.
13 September, 4-14 October 2013	58	Resampling of 192 of the previously established quadrats plus incidental records and targeted searches for Threatened and Priority Flora.
2-11 April 2014	24	Further targeted flora survey to increase the known distribution of Threatened and Priority Flora in the study area.
27 June-6 July 2016	48	Further targeted flora survey to increase the known distribution and population sizes of *Tetratheca aphylla* subsp. *aphylla* and *Lepidosperma bungalbin*.
Total	210	-



N	0 5 10km Scale MGA94 (Zone 50) CAD Ref: g2378_J5_BE_PER_C05_F05_01 Date: Aug 2016 | Rev: D | A4	Author: Mineral Resources Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax (08) 9246 3202	**J5 AND BUNGALBIN EAST FLORA AND VEGETATION STUDY AREA**

Figure: **5-1**



Source: Quadrats & Transects supplied by Ecologia (Dec 2015)
Imagery supplied by U.S. Geological Survey (July 2016)

0 3km
Scale 1:160,000
MGA94 (Zone 50)
CAD Ref: g2378_J5_BE_PER_C05_F05_28
Date: July 2016 Rev: B A4

Author: Mineral Resources
Drawn: CAD Resources ~ www.cadresources.com.au
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LOCATION OF QUADRATS AND TRANSECTS USED IN VEGETATION SURVEYS

Figure: **5-2**

Desktop analyses to complement the field surveys included database searches and reviews of other reports on surveys conducted across the region, both within and outside of the study area. Ecologia Environment (**Appendix 5-A**) reference eleven previous survey reports comprising:

- Beard's vegetation mapping for the Jackson area (Beard, 1972)
- Surveys conducted by the WA Museum (Newbey, 1985)
- Surveys conducted by the Department of Parks and Wildlife (DPaW) and previous entities (Gibson, et al., 1997; 2010; 2012)
- Surveys undertaken by specialist consultants for mining proposals (Mattiske Consulting, 2008; 2011b; Western Botanical, 2009; 2013; ecologia Environment, 2013; 2014).

To provide assurance that the surveys undertaken for MRL satisfactorily address EPA Guidance Statement No. 51, a peer review was commissioned. The peer review, conducted by Dr Grant Wardell-Johnson of Curtin University, was carried out in concert with the field surveys and included reviews of progress reports. Peer review commentary was provided in December 2013 and March 2014, with a final review in June 2015.

The three peer review components are provided as **Appendix 5-B**. Comments from the first two phases of the peer review fed into the field work, desktop assessment and compilation of the final report. The final review concluded that MRL "has met the requirements of a Level 2 flora and vegetation assessment" and did not make any further recommendations. DPaW also reviewed a draft of the ecologia Environment report and the final report included here (**Appendix 5-A**) takes the feedback received into account.

Mapping of populations and sub-populations was undertaken using DPaW guidelines (Department of Environment and Conservation, 2010). If a discrete group of point locations was more than 500 m from another discrete group of point locations, it was considered to represent a discrete population polygon. The guidelines, however, were applied flexibly depending on the situation. If populations were not separated by areas that were considered unlikely to be habitat for a particular taxon and it was likely further survey may 'fill the gap', the populations were considered as sub-populations.

To better understand the values of flora and vegetation in the study area, two further investigations were undertaken by researchers at Curtin University. These investigations were:

- an assessment of genetic diversity within populations of three target plant species - *Acacia adinophylla* (P1), *Lepidosperma bungalbin* (P1) and *Tetratheca aphylla* subsp. *aphylla* (T-DRF)
- an investigation using species distribution models (SDMs) to correlate environmental and geographic variables to occurrences of species and vegetation communities for conservation significant flora recorded on the range.

Investigations into genetic diversity aimed to:

- characterise population genetic variation, and its spatial structuring across the entire distribution of A. *adinophylla*, L. *bungalbin* and T. *aphylla* subsp. *aphylla*
- quantify any genetic variation that may be impacted by proposed mining.

SDMs are numerical tools that combine observations of species occurrence with the environmental conditions under which they occur. They provide ecological insights to identify locations where additional populations may occur or which may contain similar habitat and therefore may be suitable for translocation trials.

5.2.2 Flora

Surveys recorded 304 vascular plant taxa within the study area. The families and genera represented by the greatest number of taxa were Myrtaceae (35 taxa), Fabaceae (37 taxa) and Acacia (26 taxa), and Eucalyptus (21 taxa) respectively. The most frequently recorded taxa in the study area were *Neurachne annularis* and *Eucalyptus ebbanoensis* subsp. *ebbanoensis*.

Two taxa of threatened flora were recorded. Both are listed under the WC Act and the EPBC Act (**Table 5-3**). Both are associated with banded ironstone and are endemic to the HAR.

In addition to these two taxa, a further 16 taxa are listed as Priority Flora (**Table 5-4**), some of which are endemic to BIF (banded iron formations) and/or to the HAR. Priority Flora are taxa that may be listed as threatened in the future but which do not meet currently survey criteria, or are otherwise data deficient. Of these 16 taxa, four are classified as Priority 1 (P1), the highest Priority level. P1 species are “species that are known from one or a few locations (generally five or less) which are potentially at risk” (DPaW 2015). *Spartothamnella puberula* (P2) was recorded in surveys but this taxon has since been revised to S. *canscens* which is not a Priority Flora.

TABLE 5-3: THREATENED FLORA – CONSERVATION STATUS

Taxon	Habitat	WC Act	EPBC Act
Leucopogon spectabilis (Ironstone Beard-heath)	Shallow red-brown loam, ironstone. In rock crevices on exposed ridges.	Critically endangered	Critically endangered
Tetratheca aphylla subsp. *aphylla* (Bungalbin Tetratheca)	Red brown loam, sandy loam, banded ironstone.	Vulnerable	Vulnerable

There were no novel taxa – taxa demonstrating anomalous features that could indicate a potential new discovery - identified in the study area. Six taxa recorded range extensions of greater than 100 km. Of these, one taxon – *Sclerolaena eriacantha* – was not previously known from the Coolgardie Bioregion but is very widespread throughout the Eremaean Province.

Curtin University’s investigations using SDMs (**Appendix 5-C**) involved the use of a digital elevation model, ecologia Environment’s quadrat data (**Appendix 5-A**) and soil geochemical data from the Soil and Landscape Grid of Australia across a study area of 1,736 km^2. The SDM output indicates that species richness and local endemism were most strongly influenced by local-scale micro-topographic variability. This influence was strongly positive on the western, central and southern slopes of the HAR but much less so on north-eastern summits, presumably because these surfaces afford less protection from solar radiation. Heterogeneous BIF surfaces appear to provide a broad spectrum of specialised habitats that can accommodate a wide range of interspecific differences in habitat preference.

Overall, rarer plant taxa (Threatened and P1) are restricted to the narrower, higher elevation zone near the HAR ridgeline, with a tendency for these taxa to prefer south-facing slopes and shaded areas. North-facing slopes may have similar micro-habitats but experience greater solar radiation. This study indicates that ironstone specialist taxa may have a competitive advantage in a heterogeneous rocky environment where there may be intense competition between plants for fissures, pits and depressions that trap moisture.

Surveys recorded only ten species of environmental weed and ecologia Environment noted that weed numbers and distribution were low throughout the study area.

TABLE 5-4: PRIORITY FLORA RECORDED DURING SURVEYS

Taxon	Code	Habitat (from Appendix 5-A)	Endemic	
			BIF	HAR
Acacia adinophylla	P1	Stony loamy or sandy soils, clay. Ironstone ridges, undulating plains.	Yes	Yes
Acacia shapelleae	P1	Silty sandy loam, banded ironstone. Hill slopes, cliffs, along ridges	Yes	Yes
Beyeria rostellata	P1	Slopes and summits. Skeletal red sandy to clay soils on banded ironstone substrates.	No	No
Lepidosperma bungalbin	P1	Red loam soils with banded ironstone rock and gravel. On steep mid-slopes.	Yes	Yes
Goodenia jaurdiensis	P2	Red clayey loam with laterite or banded ironstone gravel or quartz pebbles. Low-lying plains and lower slopes.	No	No
Baeckea sp. Bungalbin Hill (B.J. Lepschi & L.A. Craven 4586)	P3	Yellow-brown sand, laterite, gravel. Moderately exposed flat sand plains.	No	Yes
Grevillea georgeana	P3	Stony loam-clay. Ironstone hilltops and slopes	Yes	No
Hibbertia lepidocalyx subsp. *tuberculata*	P3	Yellow-orange loam, ironstone gravel	Yes	No
Lepidosperma ferricola	P3	Well-drained stony loam, silty clay, banded ironstone. On rocky ledges, scree slopes, crevices and ravines	No	No
Mirbelia ferricola	P3	Skeletal orange-red loamy sand, on steep E aspect, near crest of range.	No	No
Neurachne annularis	P3	Shallow red-brown sandy loam, yellowish-red loam, with ironstone gravel or stones. Among rocks on tops, sides and bases of banded ironstone ranges	Yes	No
Philotheca coateana	P3	Red sand.	No	No
Stenanthemum newbeyi	P3	Clayey sand, clay or loam over laterite or ironstone. Hillslopes.	Yes	No
Banksia arborea	P4	Stony loam. Ironstone hills.	No	No
Eremophila caerulea subsp. *merrallii*	P4	Sand, clay or loam. Undulating plains.	No	No
Eucalyptus formanii	P4	Red sand. Ironstone slopes.	No	No
Grevillea erectiloba	P4	Gravelly loam. Lateritic ridges.	No	No

5.2.3 Vegetation

A total of 45 vegetation units were identified and mapped within the study area with the main areas of interest shown in **Figure 5-3** (legend), **Figure 5-4** (entire study area), **Figure 5-5** (Bungalbin East), **Figure 5-6** (J5) and **Figure 5-7** to **Figure 5-9** (haul road). Detailed vegetation maps of the whole study area are included in **Appendix 5-A** (Figures 9.36 to 9.46).

To identify vegetation units, quadrat data were compared using techniques described by ecologia Environment (**Appendix 5-A**, Sections 3.3 and 4.2). Vegetation unit boundaries were derived by interpreting and analysing data collected from the 197 quadrats assessed by ecologia Environment and an additional 506 quadrats from other surveys within or in close proximity to the study area (for a total of 703 quadrats). The other surveys comprise surveys for impact assessment undertaken for the J4 and Chameleon deposits, and surveys undertaken by the DPaW at Mt Helena and Aurora, the Jaurdi uplands and the Jackson Range.

Many of the vegetation units support Threatened or Priority-listed Flora. **Table 5-5** lists the vegetation units recorded within the study area which support conservation-significant flora and identifies the number of conservation significant taxa occurring in each. These taxa are most strongly represented within the PSRN vegetation units.

Ecologia Environment (**Appendix 5-A**) noted that vegetation surveys with high quadrat intensity increase the likelihood of capturing fine-scale localised vegetation units when compared to broader scale surveys. To better understand the significance of the local units in a regional context, multivariate analysis was used to divide the 45 vegetation units within the study area and the 14 additional vegetation units defined regionally into eight ‘supergroups’ (**Table 5-6**):

- Two supergroups associated with yellow sandplains (SPAC and SPAB)
- Two supergroups associated with plains (PCS and PNC)
- Two supergroups associated with banded iron formation (BIF) slopes and ridgetops (PSRN and RSWN)
- Two supergroups - miscellaneous plains (MIPL) and miscellaneous sandplains (MISP) - that did not align well with other supergroups

Estimated species richness within supergroups was determined from quadrat data (**Figure 5-10**). The PSRN supergroup had the highest species richness with 220 species while the SPAB supergroup recorded the least with only 56 species.

Vegetation condition was also assessed for each quadrat using a widely-used scale (Department of Environmental Protection, 2000). Almost all quadrats were recorded as being in very good or excellent condition, indicative of the absence of grazing by livestock and other disturbance. Many quadrats showed no evidence of fire with others showing no recent signs of fire (Table 5-7).

Database searches indicate there are no threatened ecological communities listed under the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act) or the Western Australian *Wildlife Conservation Act 1950* (WC Act).

The Department of Parks and Wildlife (DPaW) maintains a Priority list of ecological communities. Ecological communities on the Priority list (‘PECs’) have insufficient information available to be considered a threatened ecological community, or which are rare but not currently threatened (Department of Parks and Wildlife, 2015).

One PEC, the “Helena and Aurora Range vegetation complexes (banded ironstone formation)” (“HAR PEC”), occurs within the study area while a further eight PECs, all associated with Banded Iron Formations (BIF), occur within 50 km of the study area (**Figure 5-11**). The HAR PEC is listed as Priority 1, and as such has a high priority for “survey and/or definition of the community, and evaluation of conservation status”.

PCS1 Eucalyptus salmonophloia and/or Eucalyptus salubris open woodland, over Atriplex nummularia, Atriplex vesicaria, Eremophila scoparia, Olearia muelleri, and Senna artemisioides subsp. filifolia mid open shrubland, over Maireana trichoptera low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PCS2 Mixed Eucalyptus spp. open woodland, over Acacia erinacea, Atriplex nummularia, Atriplex vesicaria, Eremophila scoparia and Olearia muelleri mid open shrubland, over Sclerolaena diacantha low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PCS4 Eucalyptus longicornis open woodland, with or without Eucalyptus salubris, over Atriplex nummularia, Atriplex vesicaria and Eremophila scoparia mid shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PCS5 Atriplex vesicaria and Atriplex nummularia mid open shrubland, over Maireana georgei, Maireana trichoptera and Sclerolaena diacantha low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PCS6 Eucalyptus salubris open woodland, over Atriplex vesicaria and Eremophila scoparia mid open shrubland, over Maireana trichoptera and Sclerolaena diacantha low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PCS7 Eucalyptus ravida open woodland, over Atriplex vesicaria mid open shrubland, over Maireana trichoptera and Sclerolaena diacantha low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PNC1 Acacia acuminata and Acacia tetragonophylla tall open shrubland, over Acacia erinacea, Olearia muelleri and Scaevola spinescens mid open shrubland, over Neurachne annularis sparse tussock grassland, with or without Austrostipa elegantissima or Austrostipa platychaeta isolated grasses

PNC3 Eucalyptus corrugata open woodland, over Atriplex nummularia, Olearia muelleri, and Senna artemisioides subsp. filifolia mid open shrubland, over Maireana trichoptera and Ptilotus obovatus low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PNC5 Mixed Eucalyptus spp. open woodland, over Exocarpos aphyllus, Grevillea acuaria and Senna artemisioides subsp. filifolia tall open shrubland, over Olearia muelleri mid open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PNC6 Mixed Eucalyptus spp. open woodland, over Eremophila oppositifolia subsp. angustifolia tall open shrubland, over Acacia erinacea, Eremophila scoparia, Olearia muelleri, and Scaevola spinescens mid open shrubland, with or without Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PNC7 Eucalyptus transcontinentalis or Eucalyptus oleosa subsp. oleosa woodland, over Eremophila oppositifolia subsp. angustifolia tall open shrubland, over Atriplex nummularia and Olearia muelleri mid open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PNC8 Acacia acuminata, Acacia tetragonophylla, and Alyxia buxifolia tall open shrubland, over Eremophila decipiens and Senna artemisioides subsp. filifolia mid open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PNC9 Acacia acuminata and Acacia tetragonophylla tall open shrubland, over Atriplex vesicaria, Rhagodia drummondii mid open shrubland, over Ptilotus obovatus, Sclerolaena diacantha low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta and Austrostipa trichophylla isolated tussock grasses

PNC10 Acacia acuminata and Acacia prainii tall open shrubland, over Senna artemisioides subsp. filifolia, Eremophila decipiens subsp. decipiens mid open shrubland, over Ptilotus obovatus low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

MIPL1 Eucalyptus ebbanoensis subsp. ebbanoensis (with or without) open woodland, over Acacia resinimarginea and Hakea minyma tall shrubland, over Olearia pimelioides and Phebalium canaliculatum mid open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta sparse tussock grassland

MIPL2 Acacia acuminata tall shrubland, over Olearia pimelioides and Prostanthera grylloana mid open shrubland, over Amphipogon caricinus subsp. caricinus sparse tussock grassland

MIPL3 Mixed Eucalyptus spp. open woodland, over Acacia acuminata and Alyxia buxifolia tall shrubland, over Olearia muelleri, Scaevola spinescens, and Senna artemisioides subsp. filifolia mid open shrubland, over mixed tussock grasses

MISP4 Eremophila caperata, Olearia exiguifolia, Olearia muelleri, Westringia cephalantha var. cephalantha shrubland, over Austrostipa elegantissima or Austrostipa platychaeta sparse tussock grassland, with or without Triodia scariosa sparse hummock grassland

MISP5 Eucalyptus yilgarnensis open woodland, over Muehlenbeckia florulenta open shrubland, over Sclerolaena diacantha low open shrubland

MISP8 Eucalyptus ebbanoensis subsp. ebbanoensis or Callitris preissii open woodland, over Westringia cephalantha var. cephalantha mid open shrubland, with or without Alyxia buxifolia mid open shrubland, over Triodia scariosa or Triodia rigidissima sparse hummock grassland

MISP9 Acacia hemiteles tall open shrubland, over Atriplex vesicaria mid open shrubland, over Austrostipa spp. and Rytidosperma caespitosum sparse tussock grassland

PSRN0 Eucalyptus corrugata and Eucalyptus ebbanoensis subsp. ebbanoensis open woodland, over Acacia erinacea, Olearia muelleri and Ptilotus obovatus low open shrubland (with or without Eremophila interstans subsp. interstans) or over Eremophila clarkei, Olearia pimelioides and Ptilotus obovatus low open shrubland, over Neurachne annularis sparse tussock grassland

PSRN1 Eucalyptus ebbanoensis subsp. ebbanoensis open woodland, over Eremophila oppositifolia subsp. angustifolia tall open shrubland, over Olearia muelleri mid open shrubland, over Neurachne annularis sparse tussock grassland

PSRN2 Eucalyptus ebbanoensis subsp. ebbanoensis open woodland, over Grevillea zygoloba and Scaevola spinescens mid open shrubland, over Acacia adinophylla low open shrubland, over Neurachne annularis sparse tussock grassland

PSRN6 Banksia arborea and Eucalyptus ebbanoensis subsp. ebbanoensis open woodland, over Alyxia buxifolia mid open shrubland, over Comesperma integerrimum and Ptilotus obovatus low open shrubland, over Neurachne annularis sparse tussock grassland

PSRN7 Eucalyptus capillosa subsp. capillosa open woodland, over Alyxia buxifolia tall open shrubland, over Olearia muelleri and Ptilotus obovatus low open shrubland, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

PSRN8 Eucalyptus longissima and Allocasuarina acutivalvis subsp. acutivalvis open woodland, with or without Neurachne annularis sparse tussock grassland

PSRN9 Eucalyptus corrugata and Eucalyptus loxophleba subsp. lissophloia open woodland, over Acacia acuminata tall open shrubland, over Neurachne annularis sparse tussock grassland

PSRN12 Eucalyptus ewartiana (with or without) open woodland, over Acacia acuminata tall open shrubland, over Ptilotus obovatus low open shrubland, over Dianella revoluta var. divaricata isolated herbs, over Neurachne annularis and Austrostipa elegantissima or Austrostipa platychaeta sparse tussock grassland

PSRN13 Acacia acuminata tall open shrubland, over Solanum nummularium isolated shrubs, over Aristida contorta and Austrostipa elegantissima or Austrostipa platychaeta sparse tussock grassland

PSRN14 Eucalyptus ebbanoensis subsp. ebbanoensis open woodland (with or without), over Eremophila georgei, Grevillea zygoloba, Leucopogon sp. Clyde Hill (M.A. Burgman 1207) and Philotheca brucei subsp. brucei mid shrubland, over Dianella revoluta var. divaricata isolated herbs, over Neurachne annularis sparse tussock grassland

PSRN17 Acacia quadrimarginea and Melaleuca nematophylla tall open shrubland, over Calycopeplus paucifolius mid open shrubland, over Neurachne annularis sparse tussock grassland

PSRN18 Acacia quadrimarginea tall open shrubland, over Eremophila decipiens subsp. decipiens and Scaevola spinescens mid open shrubland, over Dianella revoluta var. divaricata isolated herbs, over Neurachne annularis sparse tussock grassland

PSRN20 Acacia aneura tall open shrubland, over Neurachne annularis sparse tussock grassland

PSRN21 Eucalyptus ebbanoensis subsp. ebbanoensis open woodland, over Acacia quadrimarginea tall open shrubland, over Calycopeplus paucifolius, Eremophila georgei, and Philotheca brucei subsp. brucei mid open shrubland, over Dianella revoluta var. divaricata isolated herbs, over Neurachne annularis sparse tussock grassland

PSRN22 Allocasuarina acutivalvis subsp. acutivalvis and Eucalyptus ebbanoensis subsp. ebbanoensis (with or without) open woodland, over Acacia quadrimarginea and Melaleuca nematophylla tall open shrubland, over Calycopeplus paucifolius, Philotheca brucei subsp. brucei and Stenanthemum newbeyi mid open shrubland, over Hibbertia lepidocalyx subsp. tuberculata low open shrubland, over Dianella revoluta var. divaricata isolated herbs, over Neurachne annularis sparse tussock grassland

PSRN23 Allocasuarina acutivalvis subsp. acutivalvis and Eucalyptus ebbanoensis subsp. ebbanoensis open woodland, over Alyxia buxifolia, Melaleuca leiocarpa and Melaleuca nematophylla tall shrubland, over Mirbelia ferricola and Stenanthemum newbeyi mid shrubland, over Lepidosperma bungalbin open sedgeland, with or without Neurachne annularis sparse tussock grassland

PSRN24 Allocasuarina acutivalvis subsp. acutivalvis, Banksia arborea and (with or without) Eucalyptus ebbanoensis subsp. ebbanoensis open woodland, over Alyxia buxifolia and Melaleuca nematophylla tall shrubland, over Stenanthemum newbeyi mid open shrubland, over Dianella revoluta var. divaricata isolated herbs, over Neurachne annularis sparse tussock grassland

RSWN1 Allocasuarina acutivalvis subsp. acutivalvis open woodland, over Leucopogon sp. Clyde Hill (M.A. Burgman 1207), Melaleuca nematophylla, Philotheca brucei subsp. brucei, and Prostanthera grylloana mid shrubland, over Dianella revoluta var. divaricata isolated herbs, over Austrostipa elegantissima or Austrostipa platychaeta isolated tussock grasses

SPAB2 Allocasuarina corniculata and Callitris preissii open woodland, over Acacia resinimarginea and Baeckea elderiana tall open shrubland, with or without Amphipogon caricinus var. caricinus sparse tussock grassland

SPAC1 Acacia effusifolia tall open shrubland, over Leucopogon sp. Clyde Hill (M.A. Burgman 1207) and Prostanthera campbellii mid open shrubland, over Amphipogon caricinus var. caricinus and Neurachne annularis sparse tussock grassland

SPAC2 Acacia effusifolia or Acacia coolgardiensis open shrubland, over Phebalium canaliculatum and Leucopogon sp. Clyde Hill (M.A. Burgman 1207) mid open shrubland, over Dianella revoluta var. divaricata isolated herbs, over Amphipogon caricinus var. caricinus sparse tussock grassland

SPAC3 Acacia effusifolia tall open shrubland, over Phebalium canaliculatum mid open shrubland, over Triodia scariosa sparse hummock grassland, over Amphipogon caricinus var. caricinus sparse tussock grassland

SPAC5 Acacia resinimarginea tall open shrubland, over Phebalium canaliculatum, Homalocalyx thryptomenoides, Keraudrenia velutina mid open shrubland, over Amphipogon caricinus var. caricinus sparse tussock grassland

SPAC6 Eucalyptus leptopoda subsp. subluta open woodland, over Acacia effusifolia tall open shrubland, over Baeckea sp. Bungalbin Hill (B.J. Lepschi, L.A. Craven 4586) and Phebalium canaliculatum mid open shrubland, with or without Amphipogon caricinus var. caricinus sparse tussock grassland

Priority and Ecological Communities

DPaW PEC Boundary - Helena and Aurora Range

Source: Vegetation supplied by Ecologia (Dec 2015)

N

CAD Ref: g2378_J5_BE_PER_C05_F05_02

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MINERAL RESOURCES

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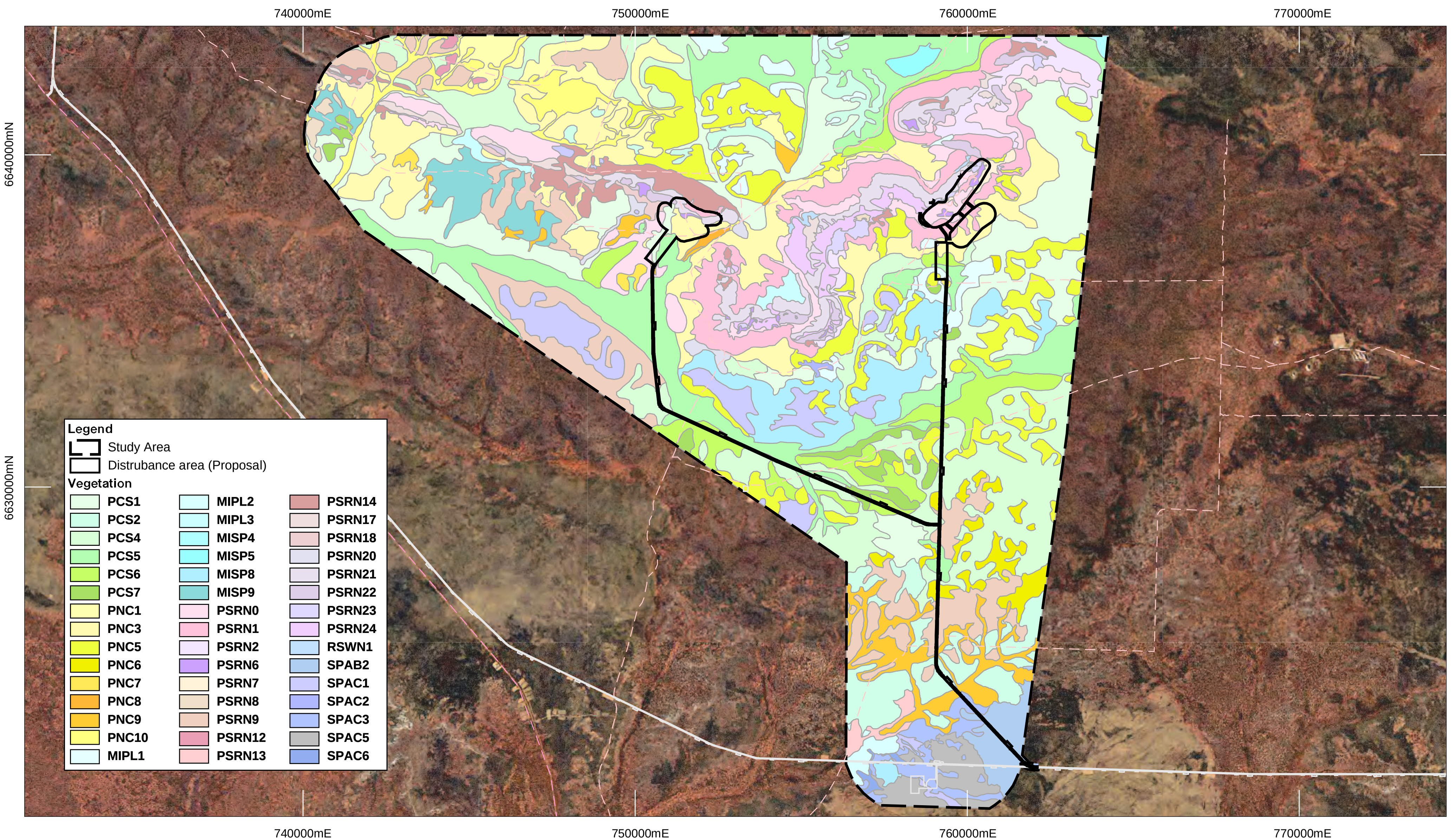
VEGETATION UNITS MAPPED WITHIN STUDY AREA (LEGEND)

Figure:

5-3



Source: Infrastructure supplied by Mineral Resources (July 2016)
Vegetation supplied by Ecologia (Dec 2015)

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Scale 1:160,000
MGA94 (Zone 50)
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Date: July 2016 | Rev: B | A4

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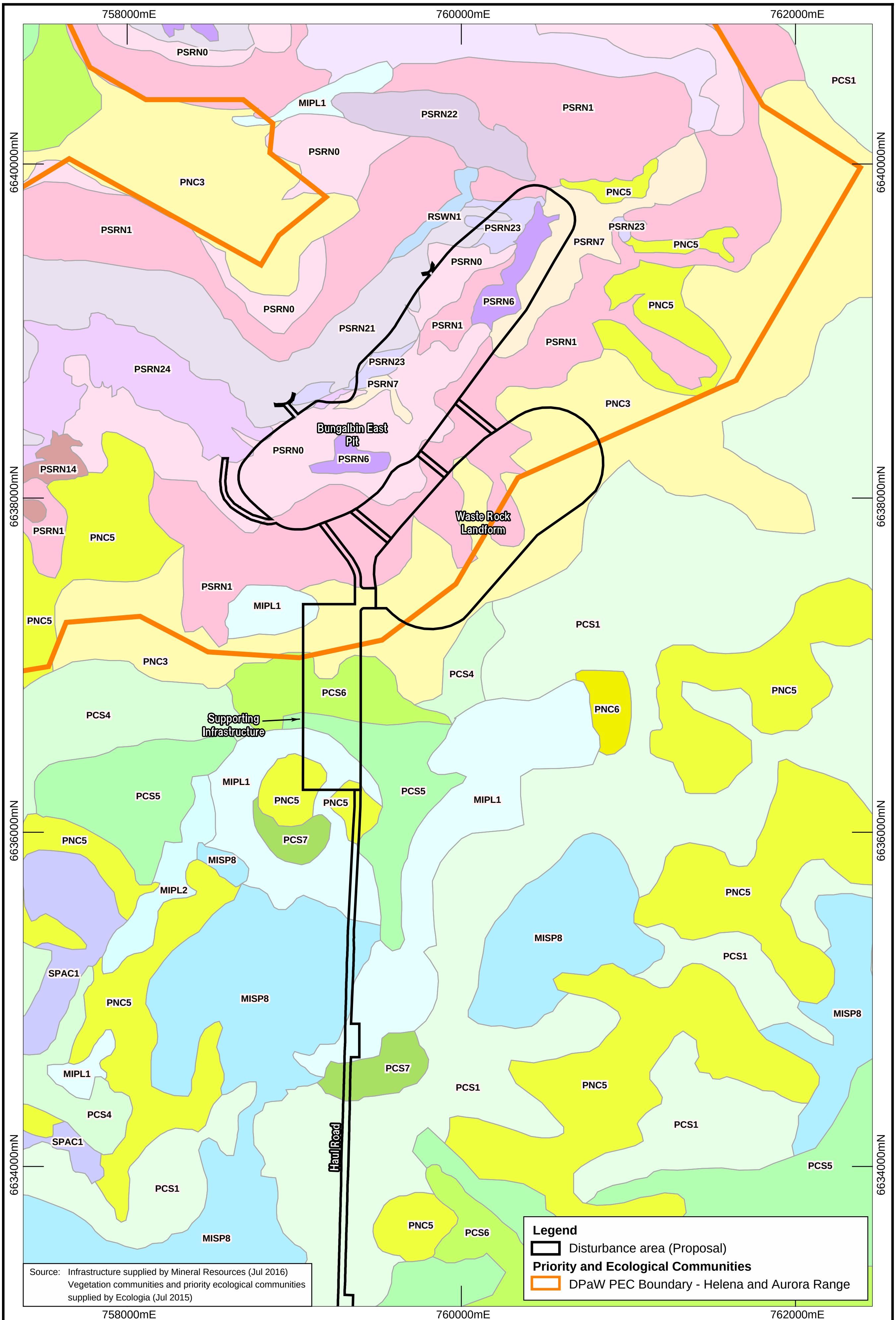
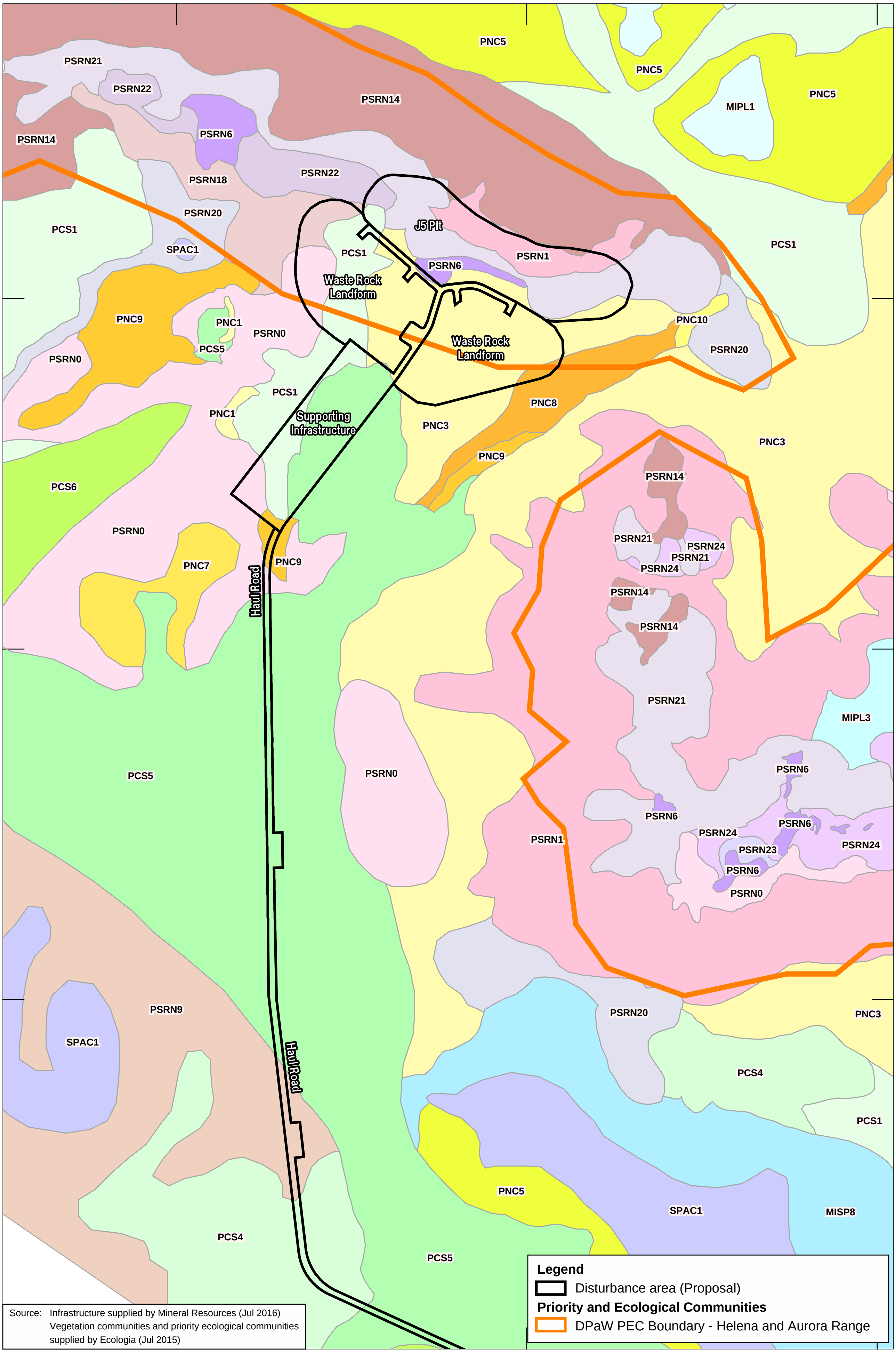
VEGETATION UNITS MAPPED WITHIN STUDY AREA (DEVELOPMENT ENVELOPE)

Figure: **5-4**



0 300 600m Scale 1:30,000 MGA94 (Zone 50) CAD Ref: g2378_J5_BE_PER_C05_F05_03 Date: Jul 2016 Rev: E A4	Author: Mineral Resources Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax (08) 9246 3202	**VEGETATION UNITS MAPPED WITHIN STUDY AREA (DETAIL - BUNGALBIN EAST)**	Figure: **5-5**



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Vegetation communities and priority ecological communities supplied by Ecologia (Jul 2015)

0 300 600m
Scale 1:30,000
MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C05_F05_04

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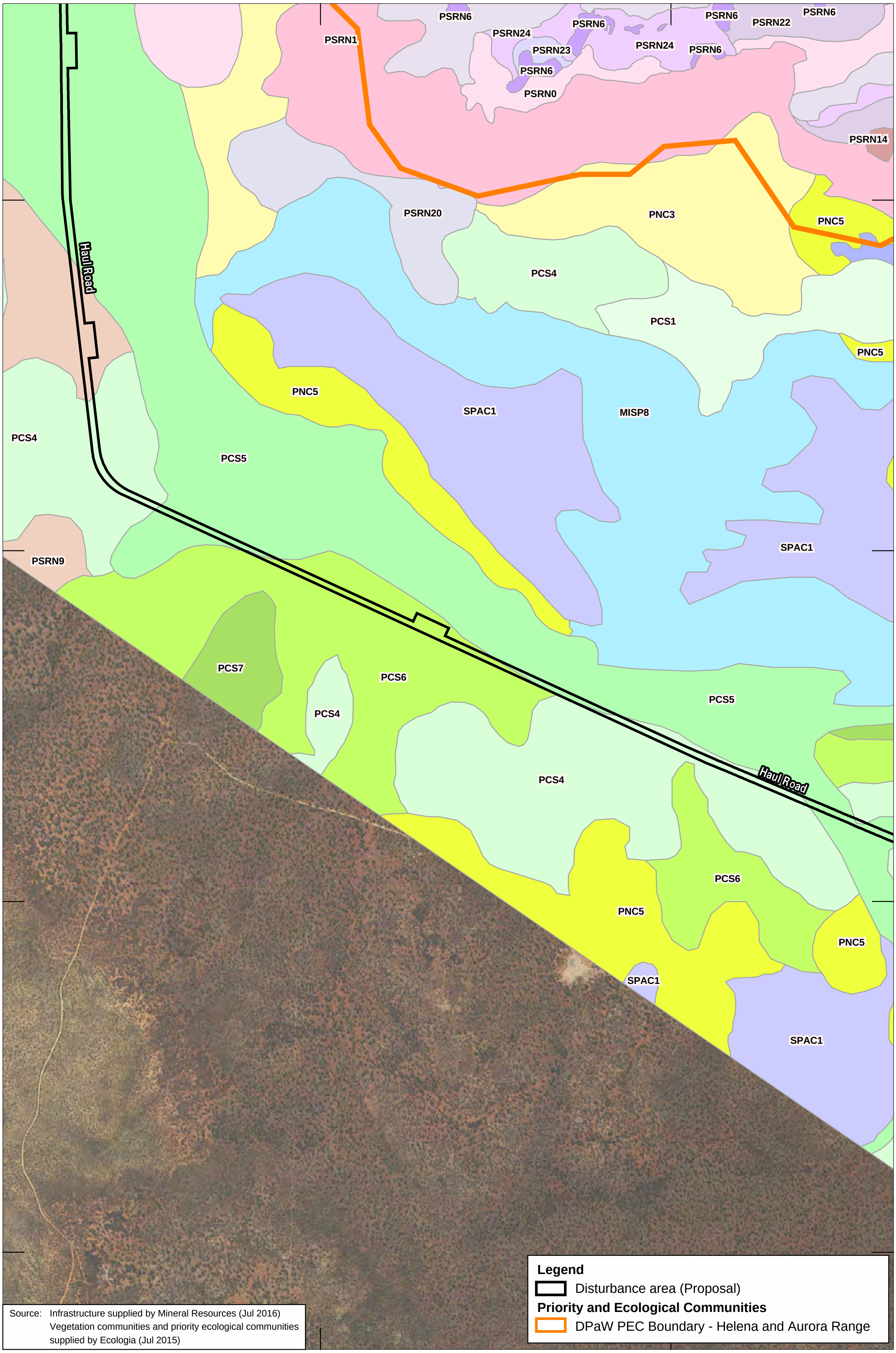
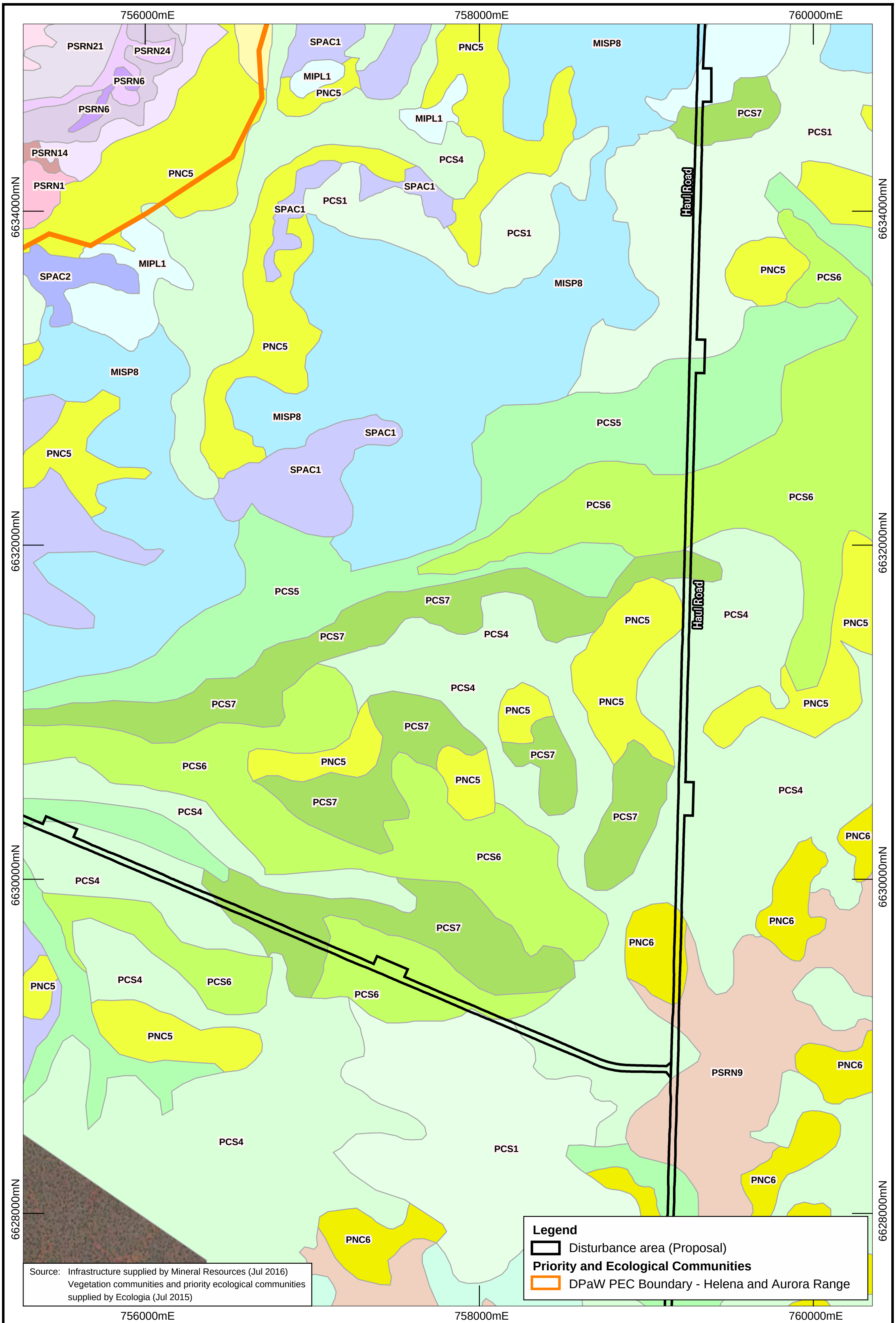
VEGETATION UNITS MAPPED WITHIN STUDY AREA (DETAIL - J5)

Figure: 5-6



0 300 600m Scale 1:30,000 MGA94 (Zone 50) CAD Ref: g2378_J5_BE_PER_C05_F05_31 Date: Jul 2016 Rev: B A4	Author: Mineral Resources Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax (08) 9246 3202	**VEGETATION UNITS MAPPED WITHIN STUDY AREA (DETAIL - HAUL ROAD FROM J5)**	Figure: **5-7**



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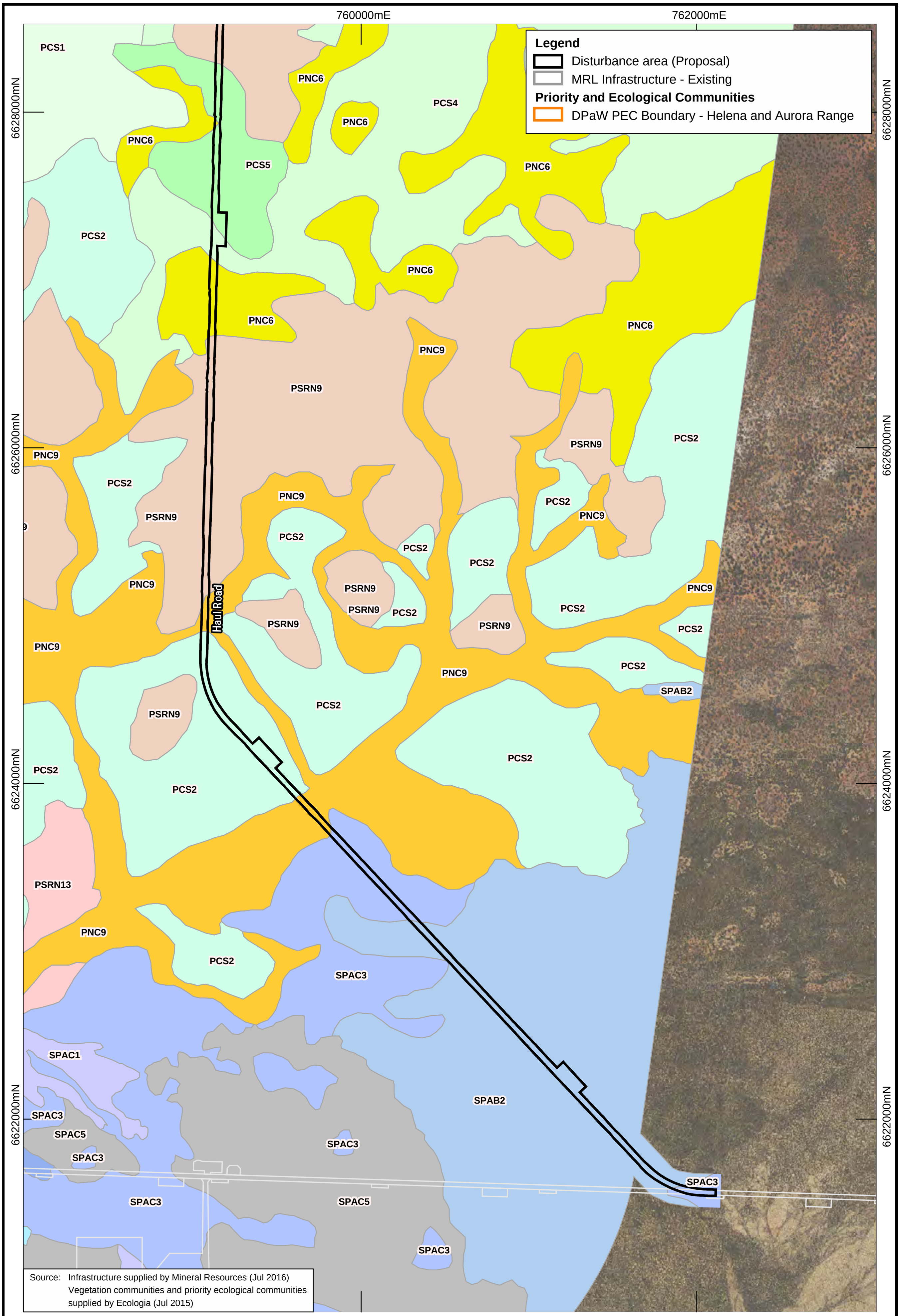
VEGETATION UNITS MAPPED WITHIN STUDY AREA (DETAIL - HAUL ROAD FROM J5 & BE)

Figure: **5-8**



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Vegetation communities and priority ecological communities supplied by Ecologia (Jul 2015)

0 300 600m Scale 1:30,000 MGA94 (Zone 50)	Author: Mineral Resources	**VEGETATION UNITS MAPPED WITHIN STUDY AREA (DETAIL - HAUL ROAD FROM J4 HAUL ROAD)**	Figure: **5-9**
CAD Ref: g2378_J5_BE_PER_C05_F05_33 Date: Jul 2016 Rev: B A4	Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax (08) 9246 3202		

TABLE 5-5: REPRESENTATION OF CONSERVATION SIGNIFICANT FLORA

Vegetation Unit	Threatened species (n)	Priority 1 (n)	Priority 2 (n)	Priority 3 (n)	Priority 4 (n)
MIPL1	-	1	-	2	2
MIPL3	1	2	-	4	1
MISP5	-	-	-	1	-
MISP8	-	1	-	3	2
PCS1	-	1	-	5	3
PCS2	-	-	-	1	-
PCS4	-	1	-	2	2
PCS5	-	3	1	5	-
PCS6	-	-	1	-	-
PCS7	-	1	-	2	-
PNC1	-	1	-	1	1
PNC3	1	3	-	6	2
PNC5	1	2	-	4	2
PNC6	-	1	-	-	-
PNC7	-	1	-	-	-
PNC8	-	-	-	1	-
PNC9	-	1	-	1	-
PNC10	-	-	-	3	-
PSRN0	1	3	-	6	3
PSRN1	1	2	-	6	3
PSRN2	2	2	-	6	1
PSRN6	2	3	-	6	3
PSRN7	1	2	-	5	3
PSRN8	2	2	-	6	1
PSRN9	-	1	-	2	-
PSRN14	1	3	-	5	2
PSRN17	1	1	-	8	1
PSRN18	-	1	-	8	1
PSRN20	1	1	-	4	3
PSRN21	2	3	-	6	3
PSRN22	2	4	-	6	2

Vegetation Unit	Threatened species (n)	Priority 1 (n)	Priority 2 (n)	Priority 3 (n)	Priority 4 (n)
PSRN23	2	2	-	6	3
PSRN24	2	4	1	7	2
RSWN1	1	1	-	5	1
SPAB2	-	-	-	1	-
SPAC1	-	2	-	4	1
SPAC2	-	-	-	1	2
SPAC3	-	-	-	3	-
SPAC5	-	1	-	2	-
SPAC6	-	-	-	1	-

TABLE 5-6: VEGETATION ‘SUPERGROUPS’ OF THE STUDY AREA

Code	Description
PCS	Plains dominated by chenopod (primarily *Atriplex* spp.) shrubs, with or without a eucalypt woodland overstorey, usually with *Austrostipa* spp.
PNC	Plains with (usually) non-chenopod shrubland, with or without a eucalypt woodland overstorey, usually with *Austrostipa* spp.
MIPL	Miscellaneous plains.
MISP	Miscellaneous sandplains, usually with *Triodia* spp., but including MISP5, the ephemeral wetland of *Eucalyptus yilgarnensis* open woodland, over *Duma florulenta* open shrubland, over *Sclerolaena diacantha* low open shrubland.
PSRN	Plains, BIF slopes and BIF ridgetops with *Neurachne annularis*.
RSWN	Rocky BIF slopes and ridgetops without *Neurachne annularis*.
SPAC	Yellow sandplains with *Acacia effusifolia*/*Acacia coolgardiensis*/*Acacia resinimarginea* and usually *Amphipogon caricinus* var. *caricinus*.
SPAB	Yellow sandplains with *Allocasuarina* spp. and *Baeckea* spp.

TABLE 5-7: VEGETATION OF STUDY AREA – FIRE HISTORY

Quadrat records	% of all quadrats
No evidence of fire	62
Not burnt within the past 5 years	36
Burnt between 2 and 5 years ago	2

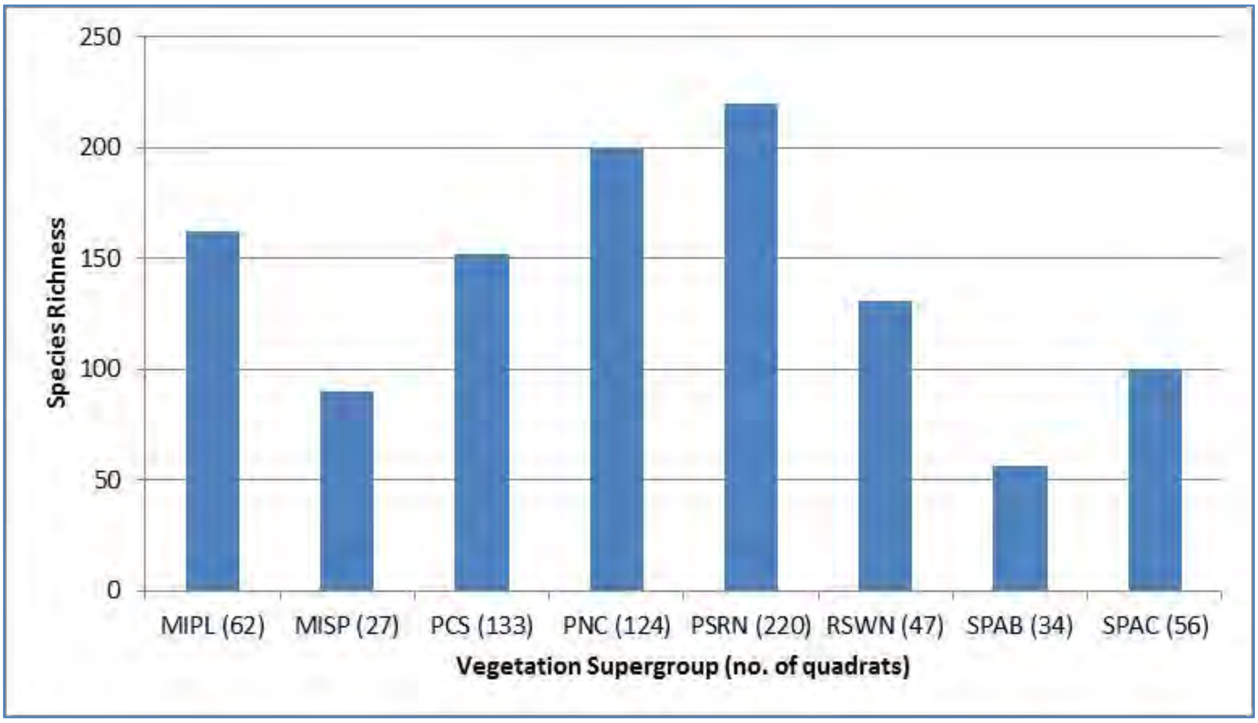


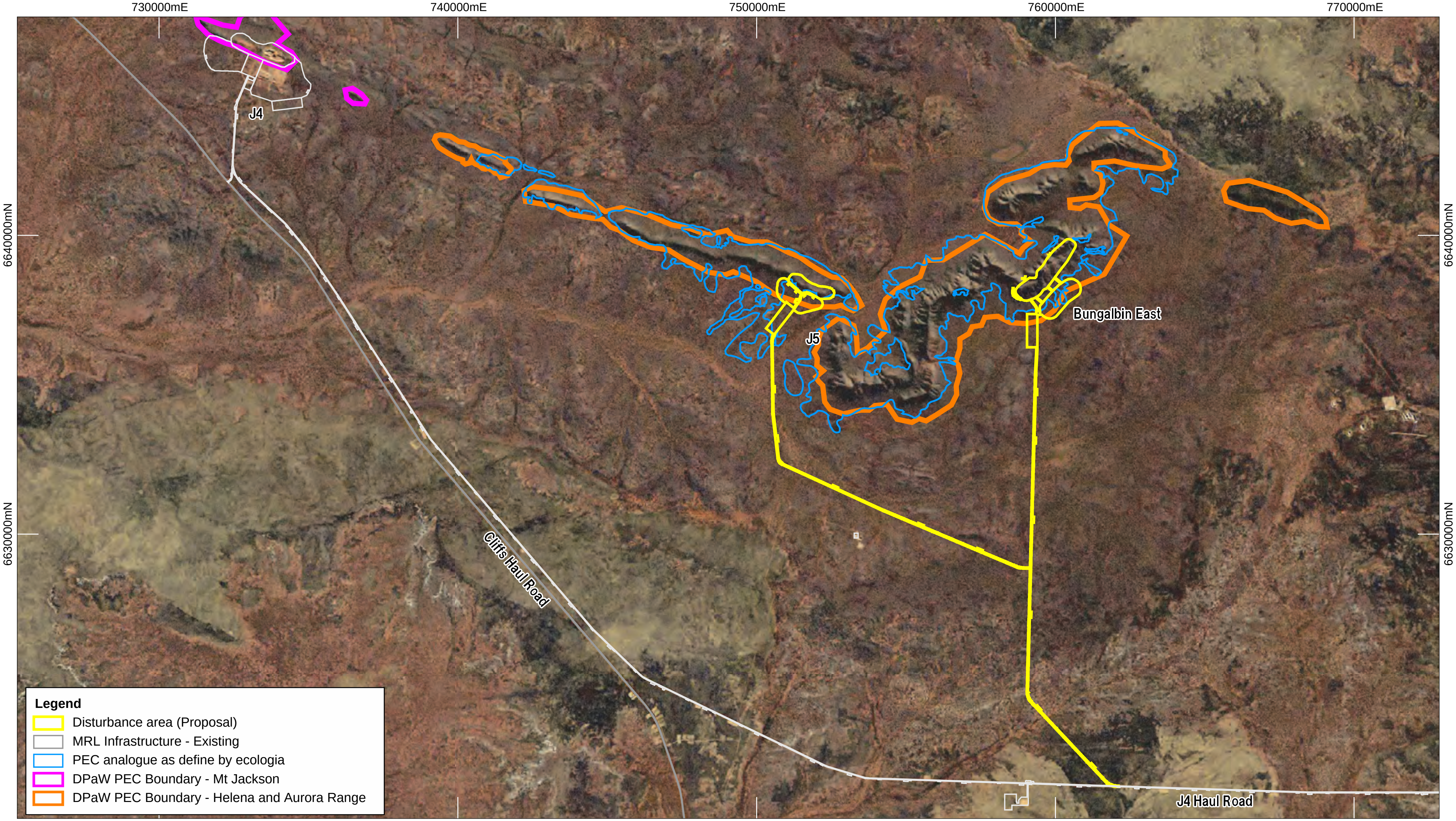
FIGURE 5-10: VEGETATION SUPERGROUPS – ESTIMATED SPECIES RICHNESS

The HAR PEC, as defined by DPaW, covers an area of 5,573.6 ha, of which 5,430.1 ha (97.4 %) occurs within the MMHARCP). The PEC is more or less fully intact with the only disturbance comprising mineral exploration and access tracks, and drill pads. This disturbance occupies a very small proportion of the PEC.

The distribution of a suite of 13 vegetation units within the PSRN supergroup identified by ecologia Environment (**Appendix 5-A**) approximate the PEC determined by DPaW, primarily due to their close association with the Helena and Aurora Range BIF (**Figure 5-11**). These thirteen vegetation units are PSRN0, PSRN1, PSRN2, PSRN 6, PSRN7, PSRN14, PSRN17, PSRN18, PSRN20, PSRN21, PSRN22, PSRN23 and PSRN 24. For the purposes of further analysis, this combination of vegetation units can be considered an analogue of the PEC ("PEC analogue").

Other vegetation units also occurring within the boundary of the HAR, but extending beyond it, are not considered by ecologia Environment to be part of the PEC analogue. The PEC analogue is broadly defined as vegetation complexes associated with the HAR, and not specifically defined floristically. Therefore, some vegetation units considered included in the PEC analogue may be more similar floristically and cluster more closely with non-PEC vegetation units (as shown in the dendrogram in **Appendix 5-A** –p90).

Thirty-six of the 45 vegetation units mapped within the study area are also present outside of the study area. One unit, MISP5, was not recorded by any of the other surveys listed in Section 5.2.1 and is likely to be locally restricted. The 13 vegetation units considered to be components of the PEC analogue, while not necessarily restricted to the HAR, may only occur on the HAR and nearby ranges (some of which are outside of the study area).



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: U.S. Geological Survey (2016)
PEC analogue as define by ecologia

N

0 1.5 3km

Scale 1:175,000
MGA94 (Zone 50)

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LOCATION OF PEC AND PEC ANALOGUE WITHIN STUDY AREA

Figure:
5-11

5.3 Potential impacts

A summary of the potential impacts of the Proposal is provided in **Table 5-8**, based on the Proposal description (Section 2), the Environmental Scoping Document (Environmental Protection Authority, 2015a) and the studies and research undertaken by MRL.

The potential direct impacts from land clearing are discussed in **Section 5.3.1**. Potential indirect impacts are discussed in **Section 5.3.1**. MRL has adopted a conservative approach to the quantification of indirect impacts for assessment purposes. A 20 m buffer around the Proposal disturbance area (excluding the haul roads) has been proposed. This area will not be cleared but, for assessment purposes, it has been assumed that all plants within the buffer are lost. In implementing the Proposal, MRL does not anticipate these indirect impacts will actually occur. The overall assessment of both direct and indirect impacts is provided in **Section 5.3.2**.

TABLE 5-8: SUMMARY OF POTENTIAL IMPACTS ON FLORA AND VEGETATION

Potential Impacts	Description
Direct	Land clearing of up to 611 ha of flora and vegetation
	Reduction in extent of vegetation of conservation significance, in particular the HAR PEC
	Reduction in extent of flora of conservation significance, including two threatened taxa
Indirect	Potential reduction in extent of conservation significant flora, including the HAR PEC
	Potential reduction in extent of conservation significant flora, including two threatened taxa
	Foliar dust deposition and loss of condition
	Rock rill from early stages of mining and blasting
	Introduction and/or spread of weeds, competition with native flora for resources.
	Fragmentation and adverse changes to microhabitats
	Impacts due to alteration of surface water flows (drainage shadows)
	Changes to fire regime
	Grazing by feral animals

5.3.1 Direct impacts on flora and vegetation

This section discusses the impact of the Proposal on flora and vegetation. In considering 'direct' losses, impacts have been calculated based on the disturbance areas shown in **Figure 5-1**, excluding the buffer area. The disturbance area includes the proposed mine layout with provision for access tracks, topsoil stockpiles and other disturbance. For the purposes of assessing impact, MRL has assumed that all flora and vegetation within the disturbance area will be removed. In practice, some land clearing within the disturbance area will not be necessary, although indirect impacts may occur.

The revised Proposal disturbance area of 611 ha, excluding an allowance for indirect impacts, has been achieved following revision of the original concept design which covered 720 ha. As outlined in **Section 2**, this has primarily been achieved by revising infrastructure requirements, partial backfilling of the Bungalbin East pit and redesign of the Bungalbin East waste rock landform.

Threatened Flora

The impact of the Proposal on threatened flora is shown in **Table 5-9**and **Figure 5-12** to **Figure 5-15**. Leucopogon spectabilis is mainly restricted to the southern end of the HAR and only a few plants (less than 1%) occur within the disturbance area.

The entire extent of L. *spectabilis* is considered to be one population owing to the relatively small total distribution of this taxon (a linear distance of less than 9 km) and the relatively small distance between the eight discrete groups of point locations (greatest distance 1.7 km, smallest distance 550 m). All plants are within conservation tenure (i.e. MMHARCP) but all are also covered by mining tenure, which can co-exist.

TABLE 5-9: DIRECT IMPACTS OF PROPOSED CLEARING ON THREATENED FLORA

Taxon	Total no. of plants recorded	No. of plants within mine disturbance area	Proposed impact (%)
Leucopogon spectabilis (Ironstone Beard-heath)	14,434	130	0.9
Tetratheca aphylla subsp. *aphylla* (Bungalbin Tetratheca)	87,921	25,887	29.4

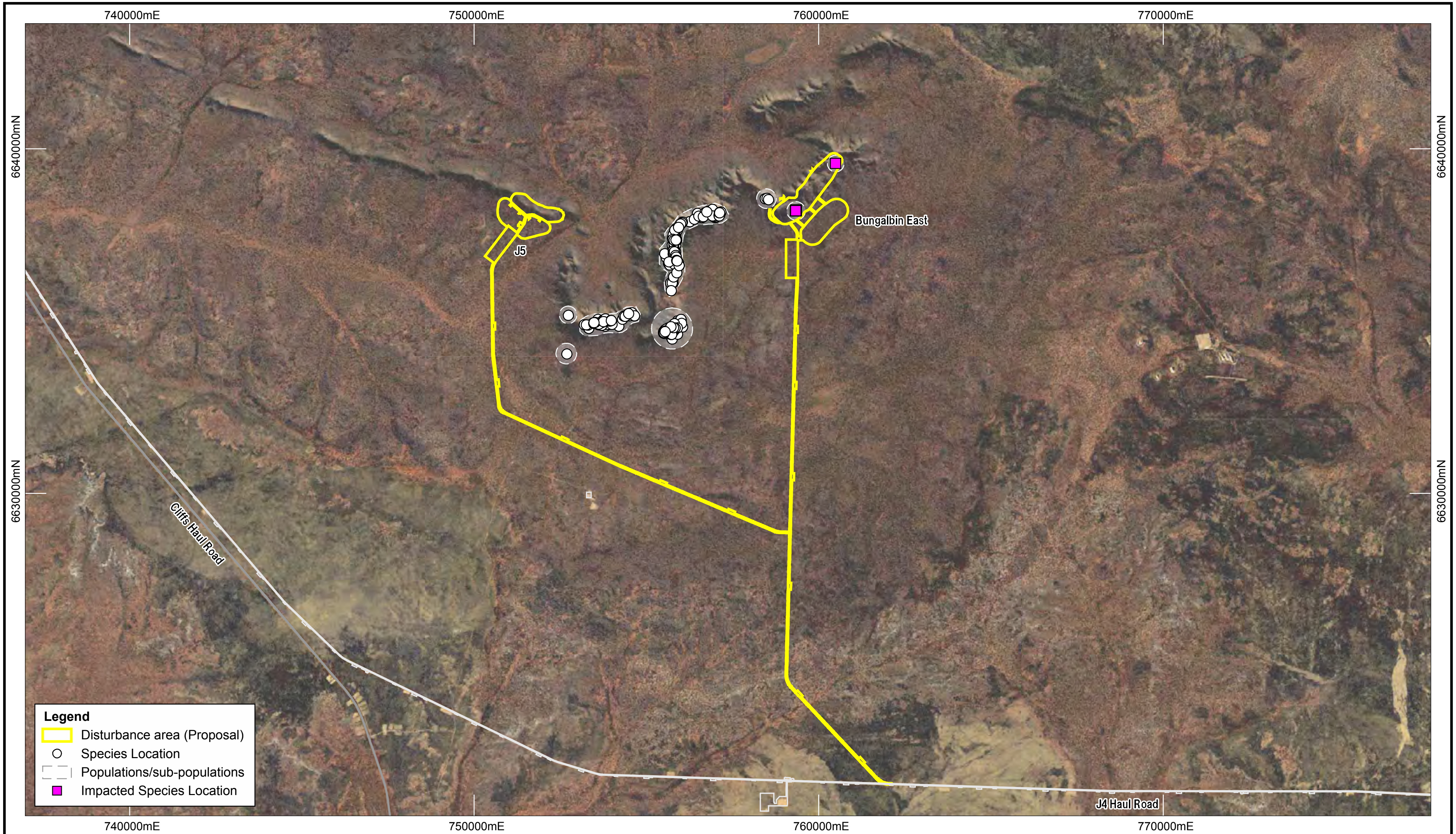
Tetratheca aphylla subsp. *aphylla* is more widely distributed across the HAR with a significant numbers of plants (over 25,000, about 29 % overall) occurring within the proposed disturbance area. One main population occurs along the ridge line with four smaller populations occurring away from the main ridge. All plants are within conservation tenure (i.e. MMHARCP) but all are also covered by mining tenure, which can co-exist.

Neither taxon is known to occur beyond the HAR although a closely-related subspecies of T. *aphylla* subsp. *aphylla* (T. *aphylla* subsp. *megacarpa*) occurs near Newdegate, WA (Threatened Species Scientific Committee, 2008). Two other records for T. *aphylla* subsp. *aphylla* occur outside the study area to the east but are assumed to be erroneous as the habitat at that location is not indicative of the preferred habitat within the study area. All known plants of both T. *aphylla* subsp. *aphylla* and L. *spectabilis* taxa occur within the MMHARCP.

An Interim Recovery Plan for L. *spectabilis* was issued in 2010 (Threatened Species Scientific Committee, 2010; Department of Environment and Conservation, 2010). The plan identified a total population of less than 1,000 plants, a number that has been increased more than 14-fold by the botanical surveys conducted for this Proposal.

Given the likelihood that the taxon is restricted to the HAR, the Interim Recovery Plan states that "on-ground works should not be approved unless the proponents can demonstrate that their actions will have no significant negative impact on the taxon, its habitat or potential habitat or on the local surface hydrology, such that drainage in the habitat of the taxon would be altered." As the impact on known plants is less than 1% and that the remaining habitat will be unaltered, the impact on this taxon is not significant.

A review by Bioscope Environmental (**Appendix 5-D**) considered the effect the Proposal would have on the threat category of this taxon with reference to the International Union for the Conservation of Nature (IUCN) Red List. It concluded that the current category of threat for L. *spectabilis* of "Critically Endangered" should not change if the Proposal is implemented. Based on the accepted IUCN criteria, L. *spectabilis* could be described as Vulnerable rather than Critically Endangered as it is considered that neither the taxon nor its habitat is being exposed to a continuing decline.



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Prioirty species supplied by Ecologia, Mattiske Consulting Pty Ltd & DPaW
Imagery: U.S. Geological Survey (2016)
Populations/sub-populations by Woodman Environmental Consulting Pty Ltd

0 1.5 3km
Scale 1:150,000
MGA94 (Zone 50)

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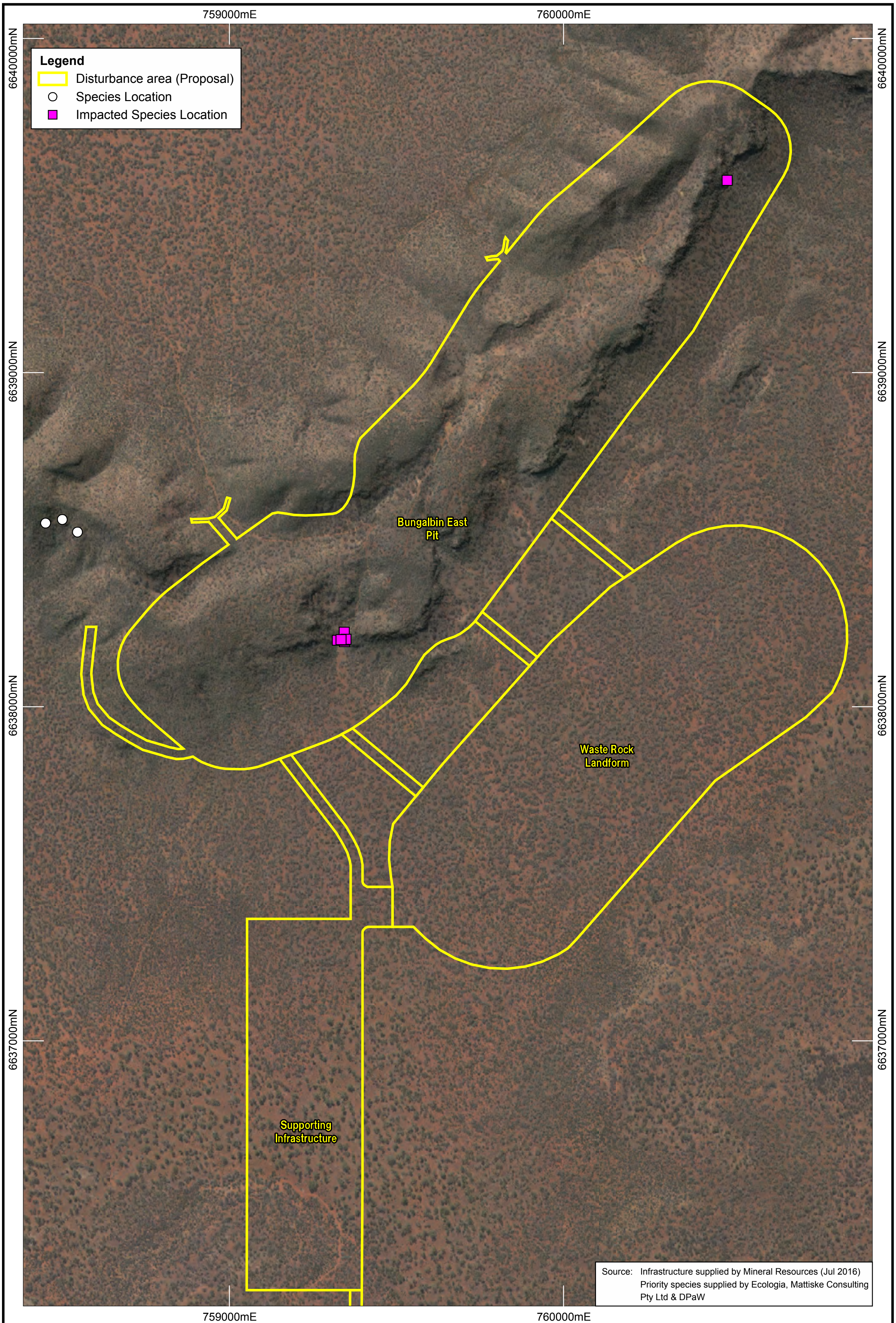
IMPACT ON
LEUCOPOGON SPECTABILIS
(THREATENED)

Figure:
5-12



0 150 300m Scale 1:15,000 MGA94 (Zone 50)	Author: Mineral Resources	**IMPACT ON *LEUCOPOGON SPECTABILIS* (THREATENED) (DETAILED)**	Figure:
CAD Ref: g2313_J5_BE_PER_C05_F05_14	Drawn: CAD Resources ~ www.cadresources.com.au		**5-13**
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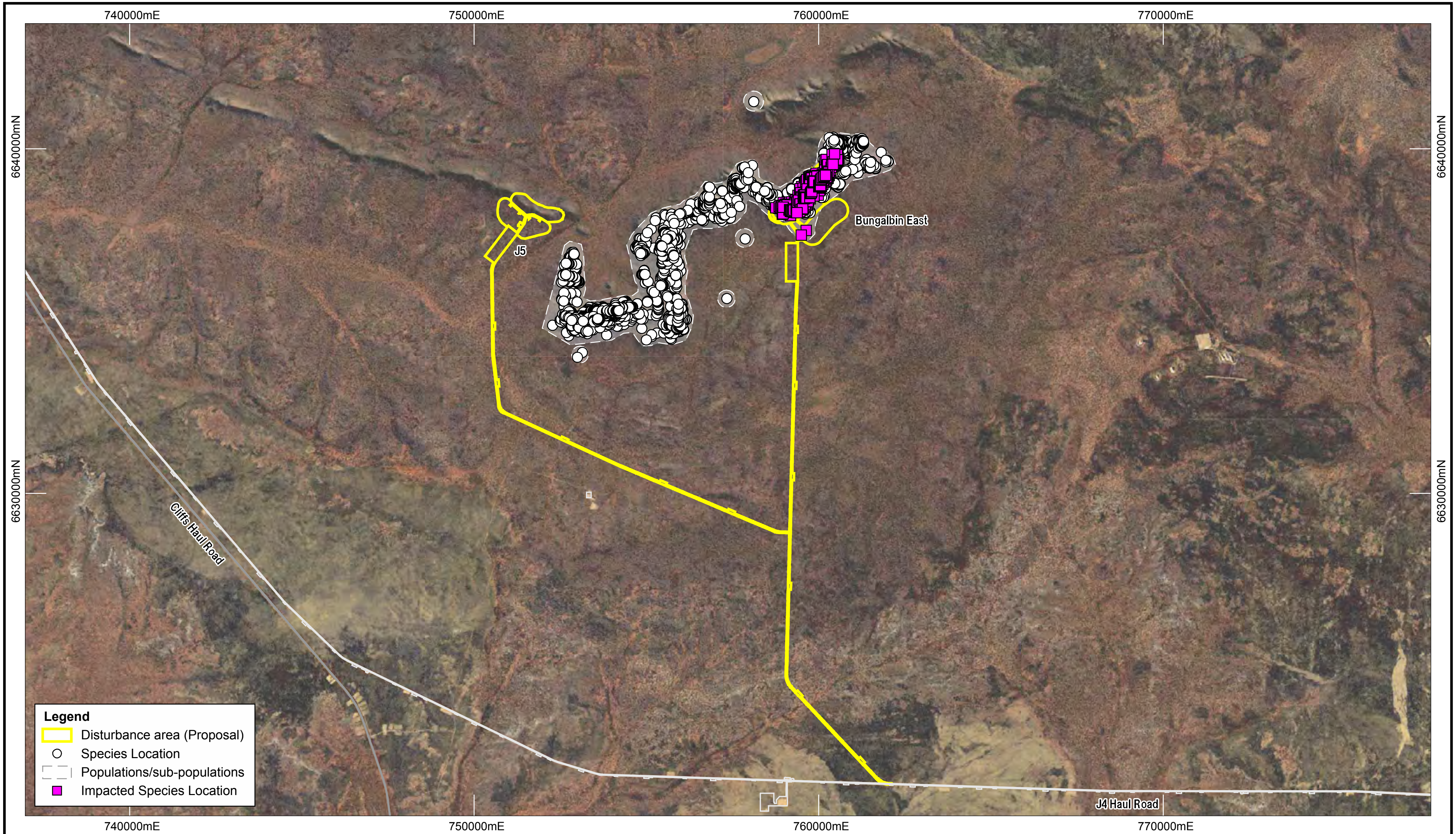

Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Prioirty species supplied by Ecologia, Mattiske Consulting Pty Ltd & DPaW
Imagery: U.S. Geological Survey (2016)
Populations/sub-populations by Woodman Environmental Consulting Pty Ltd

0 1.5 3km
Scale 1:150,000
MGA94 (Zone 50)

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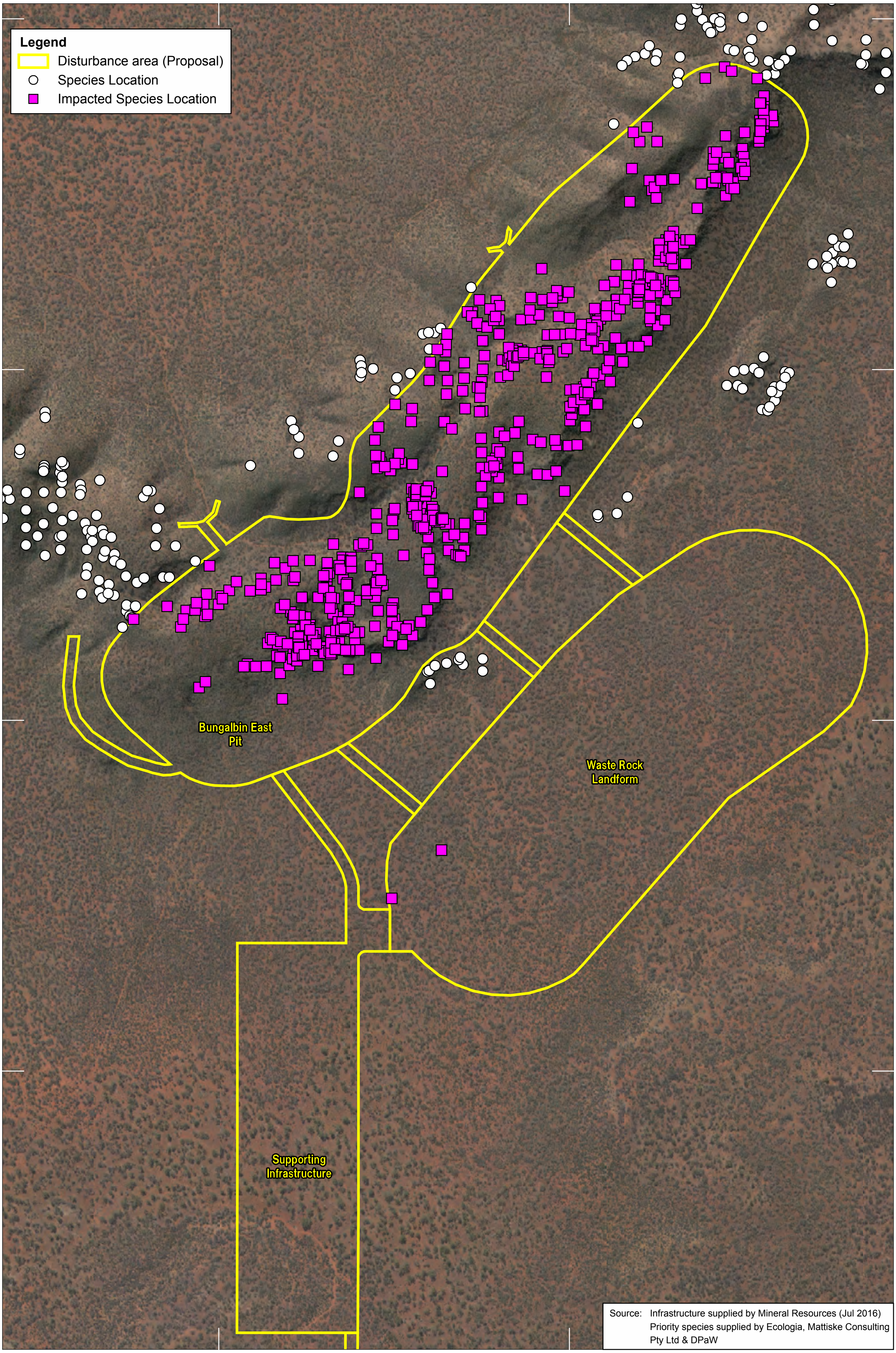
IMPACT ON *TETRATHECA APHYLLA* SUBSP. *APHYLLA* (THREATENED)

Figure: **5-14**



0 150 300m

Scale 1:15,000
MGA94 (Zone 50)

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IMPACT ON *TETRATHECA APHYLLA* SUBSP. *APHYLLA* (THREATENED) (DETAILED)

Figure: **5-15**

With regard *to Tetratheca aphylla* subsp. *aphylla*, the taxon is locally abundant from Bungalbin Hill to 5 km north east across the central section of the HAR (**Figure 5-14**). The Proposal will have a direct impact on about 28 % of all plants but over 60,000 plants will not be directly impacted.

Genetic studies by Curtin University (**Appendix 5-E**) identified that there could be a significant loss of genetic variation within T. *aphylla* subsp. *aphylla*. The study noted 11 % of total alleles[1] and 65 % of private alleles recorded during genetic testing would be removed from the overall population by the loss of plants within the Proposal disturbance area, although several other measures of genetic variation remained unchanged as a result of the Proposal.

Examination of the Proposal disturbance area with the distribution of this taxon (**Figure 5-15**) indicates that the population at Bungalbin Hill will not be fragmented to the extent that plants become isolated.

Bioscope Environmental (**Appendix 5-D**) also considered the effect of the Proposal on the IUCN threat category for T. *aphylla* subsp. *aphylla*. Bioscope concluded that the current category of threat for T. *aphylla* subsp. *aphylla* of “Vulnerable” should not change if the Proposal is implemented.

Comparison can be made with a related taxon, *Tetratheca paynterae* subsp. *paynterae* from the Windarling Range, 120 km northwest of Bungalbin Hill. In this case, a restricted population of 7,005 plants was identified through survey on unreserved land, some of which occurred within the proposed disturbance area of a mining operation. While the mining proposal was initially rejected by the EPA, conditional approval under the EP Act was eventually forthcoming. A permit to take up to 30 % of the total number of plants was granted, with an option to take a further 20 % subject to other conditions being met.

After more than ten years of mining at Windarling the population comprises approximately 5,400 plants and the option to take a further 20 % has not been exercised (Cliffs Asia Pacific Iron Ore Pty Ltd, 2014). During this period, a significant understanding of the biology of the taxon has been accumulated through research and monitoring. While the proposed impact of the J5 and Bungalbin East Proposal on T. *aphylla* subsp. *aphylla* is about 28 %, the total population size of T. *aphylla* subsp. *aphylla* is almost tenfold that of T. *paynterae* subsp. *paynterae*. Based on the Windarling experience, the risk to the conservation of T. *aphylla* subsp. *aphylla* is considered manageable and of less significance.

Priority Flora

As well as the impacts on the two threatened taxa, impacts on other taxa have also been considered. **Table 5-10** lists the impacts of the proposed land clearing on four species listed by DPaW as P1.

TABLE 5-10: DIRECT IMPACTS ON PRIORITY 1 FLORA

Taxon	Total no. of plants recorded	No. of plants within mine disturbance area	Proposed impact (%)
Acacia adinophylla	10,529	1,297	12.3
Acacia shapelleae	1,320	16	1.2
Beyeria rostellata	568	0	0
Lepidosperma bungalbin	45,976	18,233	39.7

[1] An allele is an alternative form of a gene. Detecting differences in alleles between different plants is one means of assessing genetic variation within a population. Private alleles are those restricted to a particular population.

The distribution of *Acacia adinophylla* is shown in **Figure 5-16** through to **Figure 5-18**. While restricted to the HAR, it is abundant at Bungalbin Hill and on the footslopes of the ridgeline to the northeast. There is sufficient separation distance between plants for fourteen populations to be recognised. The impact associated with clearing would primarily be within the disturbance area of the Bungalbin East mine pit but impacts also occur at other locations.

The impact on A. *adinophylla* of 12.3 % of all known plants is not likely to change the conservation status of the taxon due to the number of plants remaining. Curtin University's work on population genetics (**Appendix 5-E**) determined that the removal of plants within the proposed disturbance area would have a negligible impact on genetic variation and spatial genetic structuring within this taxon. The Proposal therefore will not have a significant impact on A. *adinophylla*.

L. *bungalbin* is a Priority 1 flora taxon, meaning that the taxon is rare, but there is inadequate information to assess this taxon for formal listing under the WC Act. The distribution of L. *bungalbin* is shown in **Figure 5-19** and **Figure 5-20**. This taxon is endemic to the HAR but is locally abundant on steep BIF slopes. All known plants occur within the MMHARCP. It occurs from Bungalbin Hill extending along the ridge to the north east over a distance of about 10 km with sufficient separation for nine populations to be recognised. MRL expects that, with the availability of the survey data produced for this Proposal, further assessment of the conservation status of this taxon under the WC Act or the EPBC Act could occur.

Based on the available data, L. *bungalbin* is most common within the disturbance area associated with the Bungalbin East mine pit. Consequently, 39.3 % of all known plants of this taxon would be removed by land clearing.

Curtin University's assessment of the impact on genetic variation and spatial genetic structuring (**Appendix 5-E**) reported a loss of 3 % of alleles for L. *bungalbin* while other parameters of genetic variation were unaffected. Most of the plants proposed to be removed belong to a distinct genetic cluster that would not be removed in its entirety but would be substantially reduced.

If the Proposal was implemented, on current information, the taxon would be considered as Vulnerable under IUCN criteria A3 and A4 as less than half the known population would be cleared (**Appendix 5-F**).

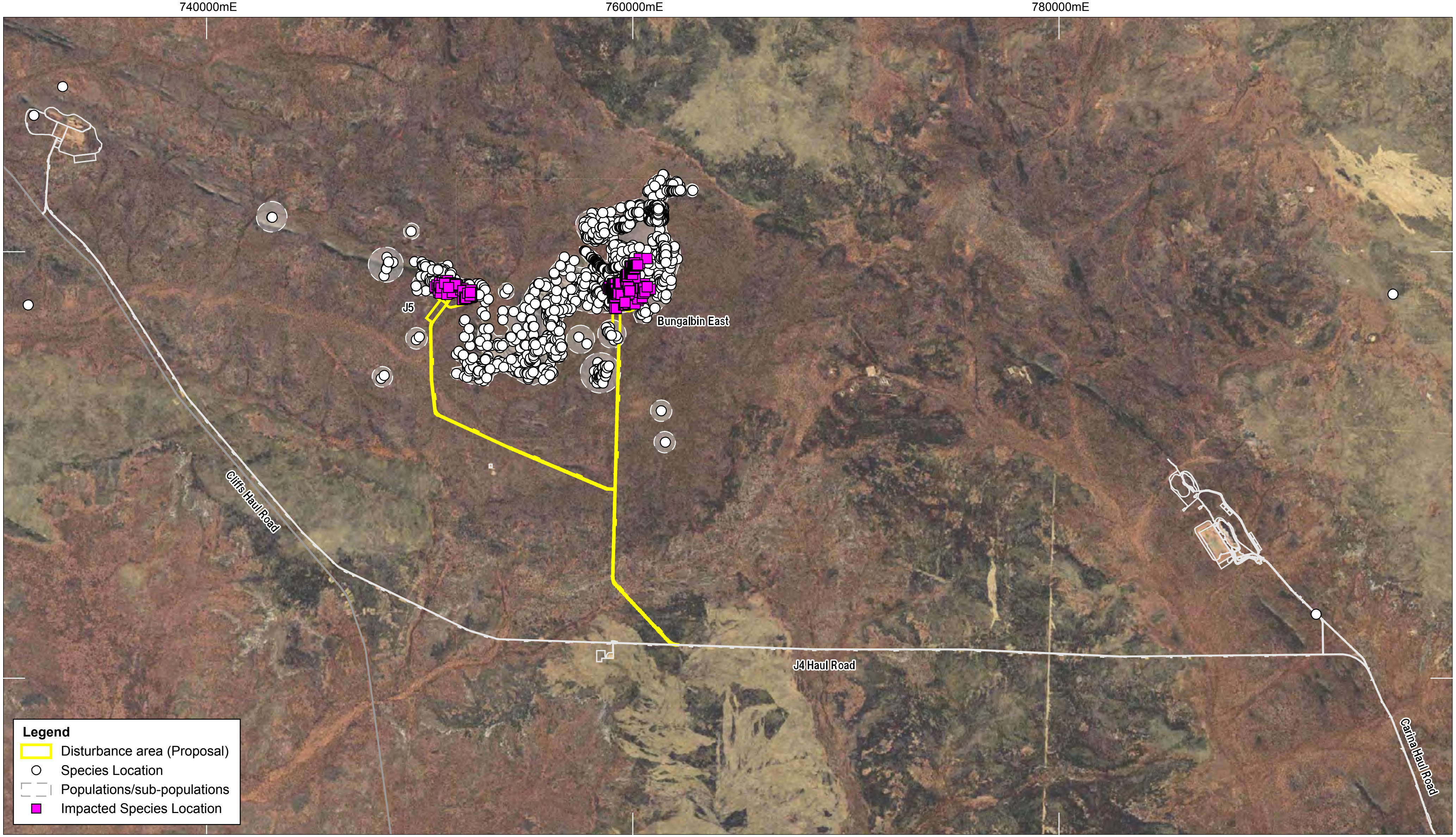
The impacts on the two remaining P1 taxa, *Acacia shapelleae* and *Beyeria rostellata*, are minor and nil, respectively, and are not considered further in this assessment. Maps showing the distribution of these taxa within the study area are shown in **Appendix 5-A** (Figures 9.20 and 9.21).

Surveys recorded one P2 taxon - *Goodenia jaurdiensis*. Two individual plants were recorded at two different locations (see **Appendix 5-A**, Figure 9.9). The taxon was recorded in surveys but both occurrences were well outside of the Proposal disturbance area. The Proposal will have no impact on this taxon.

With regard to P3 and P4 taxa, three taxa - *Baeckea* sp. *Bungalbin Hill* (B.J. Lepschi & L.A. Craven 4586) (P3), *Philotheca coateana* (P3) and *Eremophila caerulea* subsp. *merrallii* (P4) – were recorded during surveys but do not occur within or near the Proposal disturbance area and will not therefore be impacted by the Proposal.

Direct impacts on other P3 and P4 taxa are summarised in **Table 5-11**. Data on plant numbers from other surveys conducted in the Koolyanobbing, Jackson and Windarling Ranges is included to give a broader picture of the potential impacts at a regional scale.

Direct impacts on P3 and P4 Priority Flora are less than 10 % for all taxa except *Stenanthemum newbeyi* (P3) (**Figure 5-21**) and *Banksia arborea* (P4) (**Figure 5-22**). Both taxa occur widely across BIF ridges in the region and at least ten populations of each occur locally.



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Prioirty species supplied by Ecologia, Mattiske Consulting Pty Ltd & DPaW
Imagery: U.S. Geological Survey (2016)
Populations/sub-populations by Woodman Environmental Consulting Pty Ltd

0 2 5km
Scale 1:250,000
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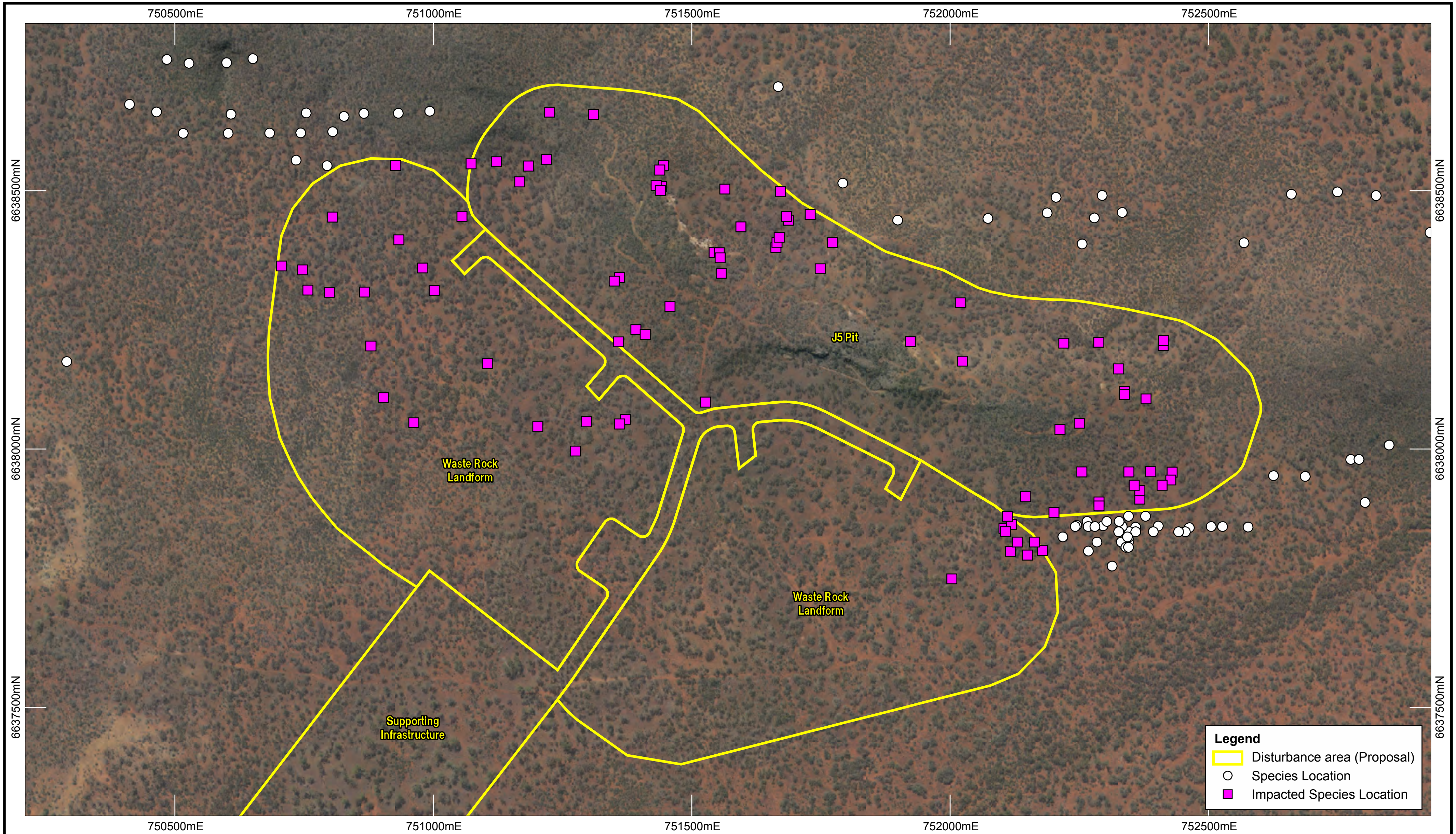
IMPACT ON *ACACIA ADINOPHYLLA* (P1)

Figure: **5-16**



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Priority species supplied by Ecologia, Mattiske Consulting Pty Ltd & DPaW

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CAD Ref: g2313_J5_BE_PER_C05_F05_16
Date: July 2016 | Rev: E | A4

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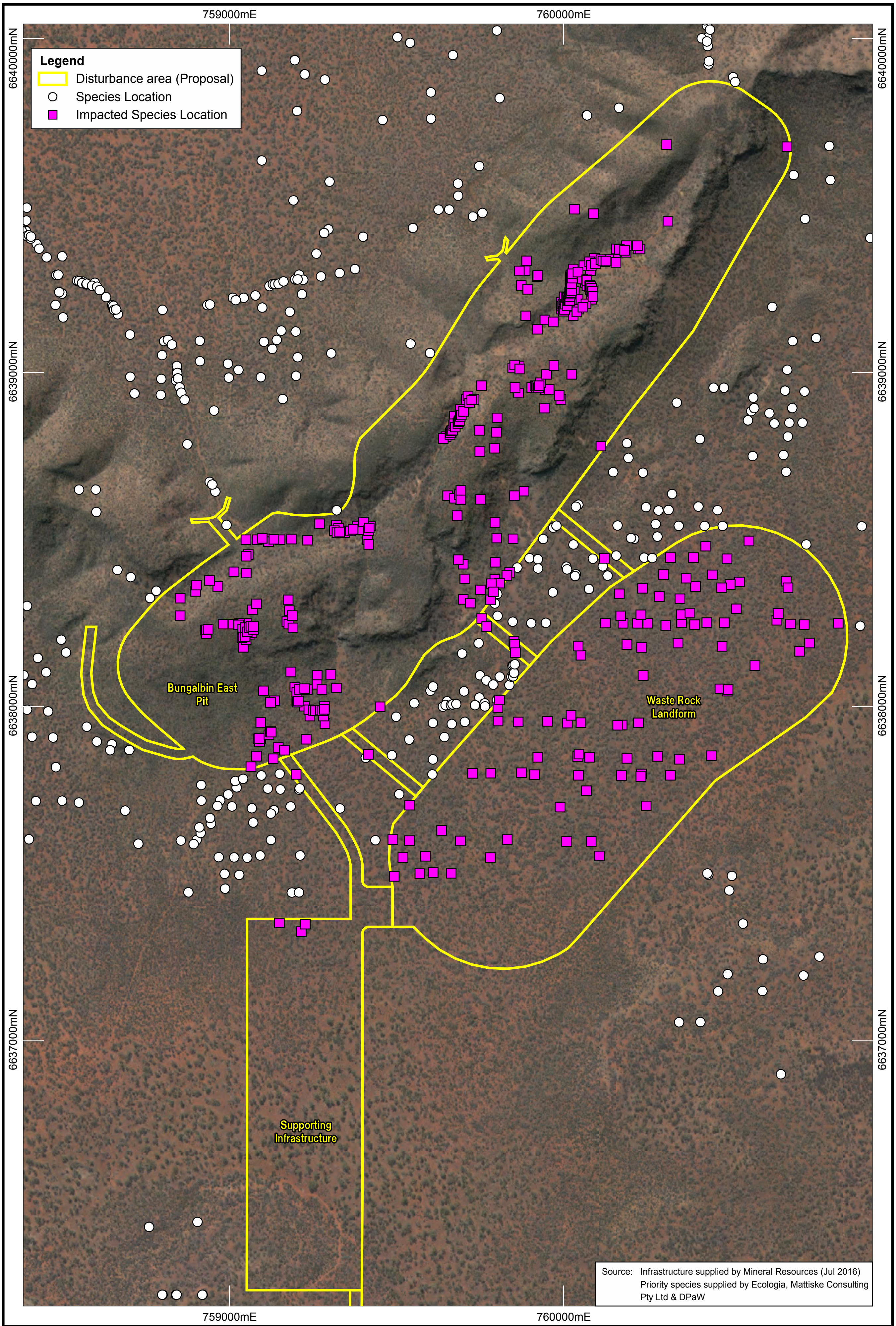
IMPACT ON *ACACIA ADINOPHYLLA* (P1) (DETAIL - J5)

Figure: **5-17**



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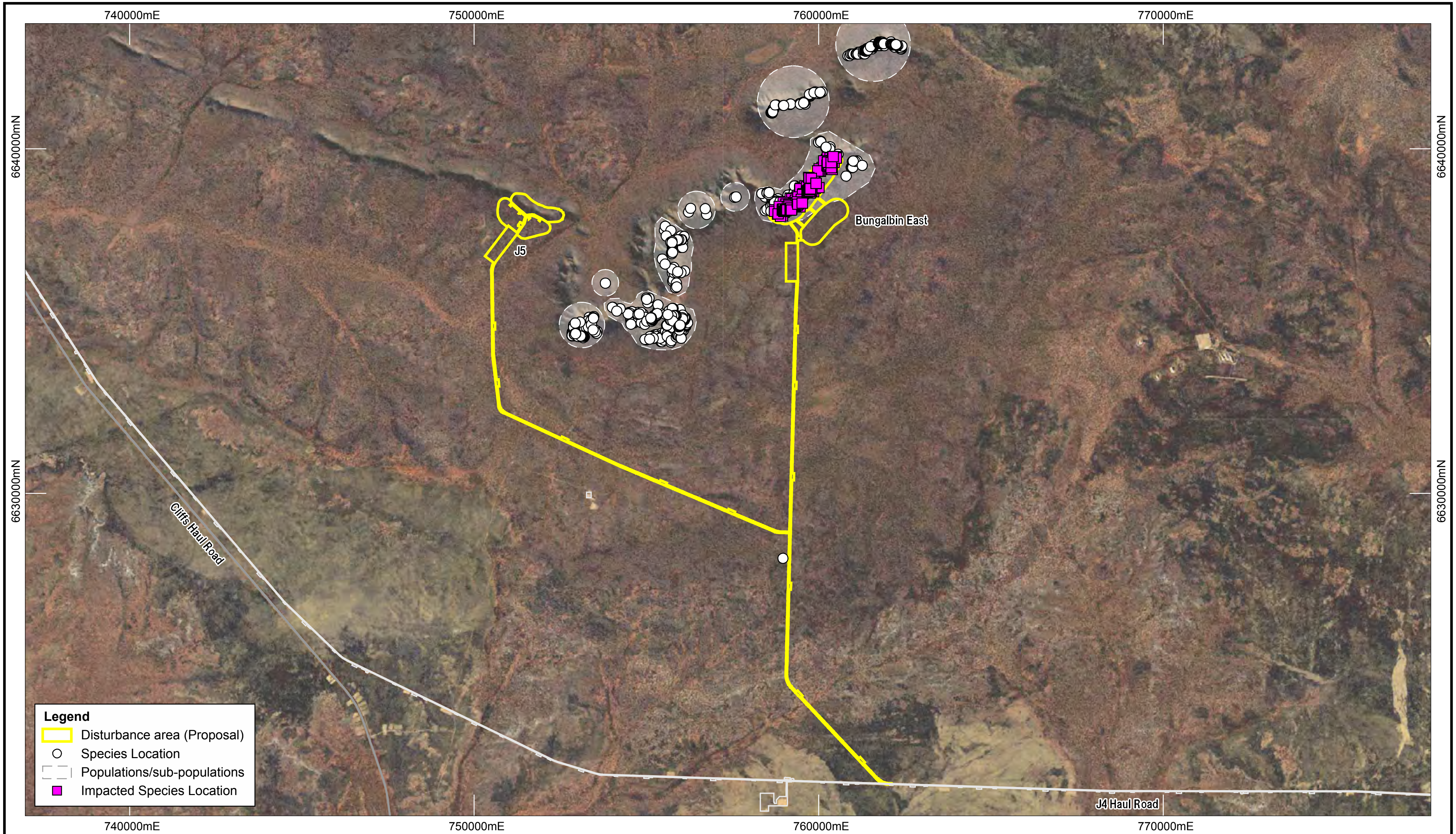
IMPACT ON *ACACIA ADINOPHYLLA* (P1)
(DETAIL - BUNGALBIN EAST)

Figure:
5-18



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Prioirty species supplied by Ecologia, Mattiske Consulting Pty Ltd & DPaW
Imagery: U.S. Geological Survey (2016)
Populations/sub-populations by Woodman Environmental Consulting Pty Ltd

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Scale 1:150,000
MGA94 (Zone 50)
CAD Ref: g2313_J5_BE_PER_C05_F05_12
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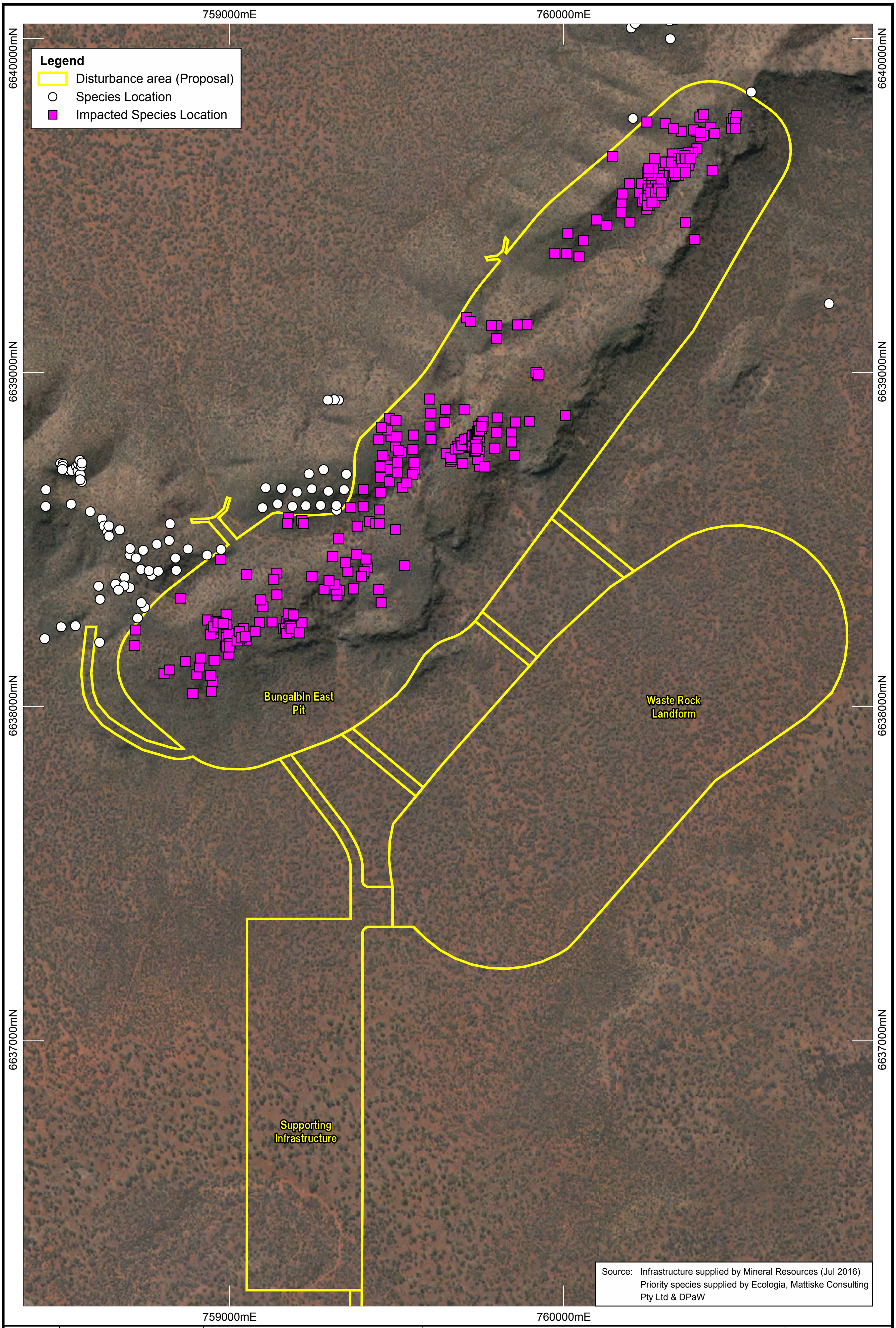
IMPACT ON
***LEPIDOSPERMA BUNGALBIN* (P1)**

Figure:
5-19



0 150 300m

Scale 1:15,000
MGA94 (Zone 50)

CAD Ref: g2313_J5_BE_PER_C05_F05_18

Date: July 2016 | Rev: E | A4

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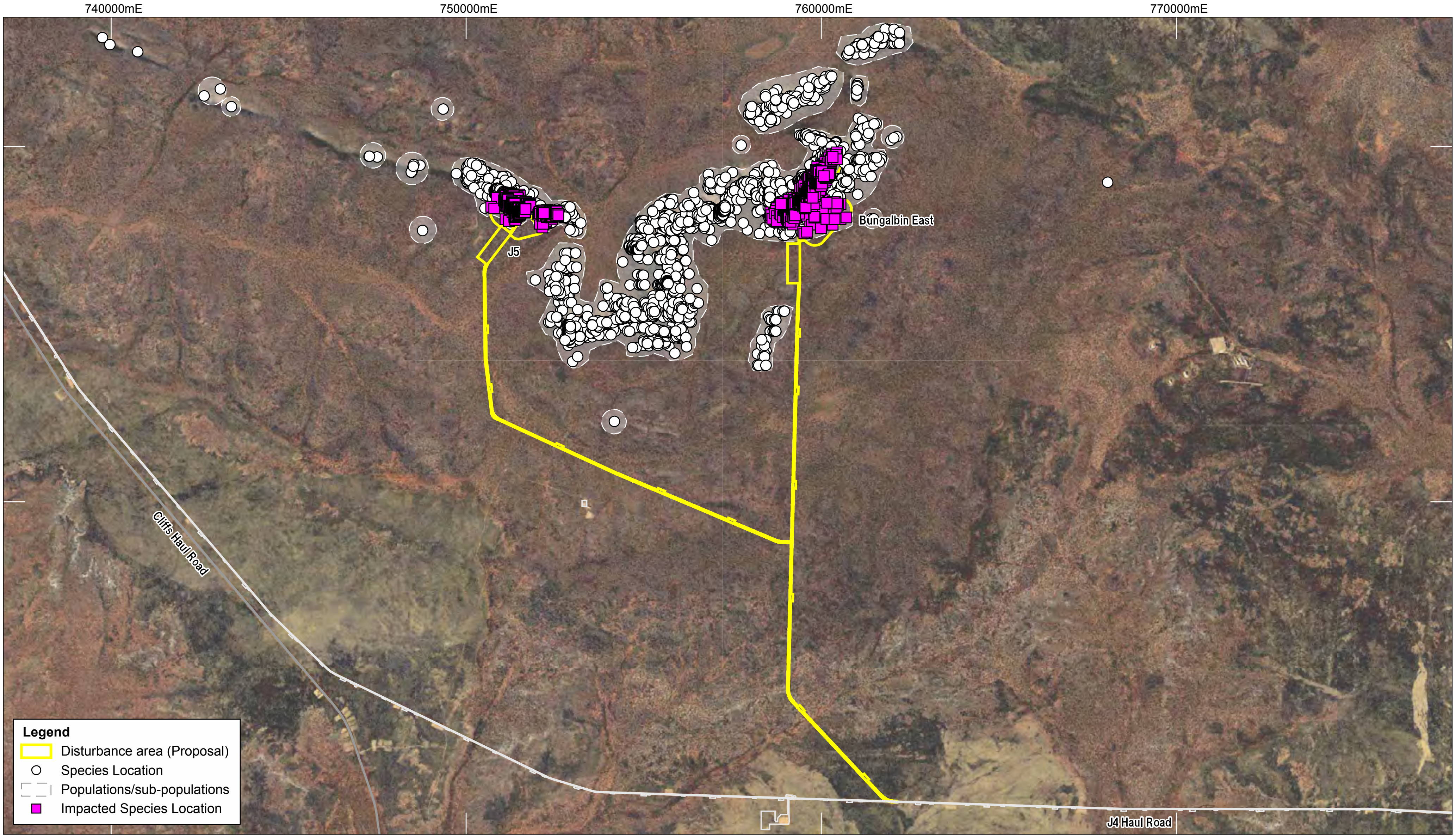
IMPACT ON *LEPIDOSPERMA BUNGALBIN* (P1) (DETAIL)

Figure: **5-20**



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Prioirty species supplied by Ecologia, Mattiske Consulting Pty Ltd & DPaW
Imagery: U.S. Geological Survey (2016)
Populations/sub-populations by Woodman Environmental Consulting Pty Ltd

0 1.5 3km
Scale 1:150,000
MGA94 (Zone 50)
CAD Ref: g2313_J5_BE_PER_C05_F05_24
Date: July 2016 | Rev: D | A4

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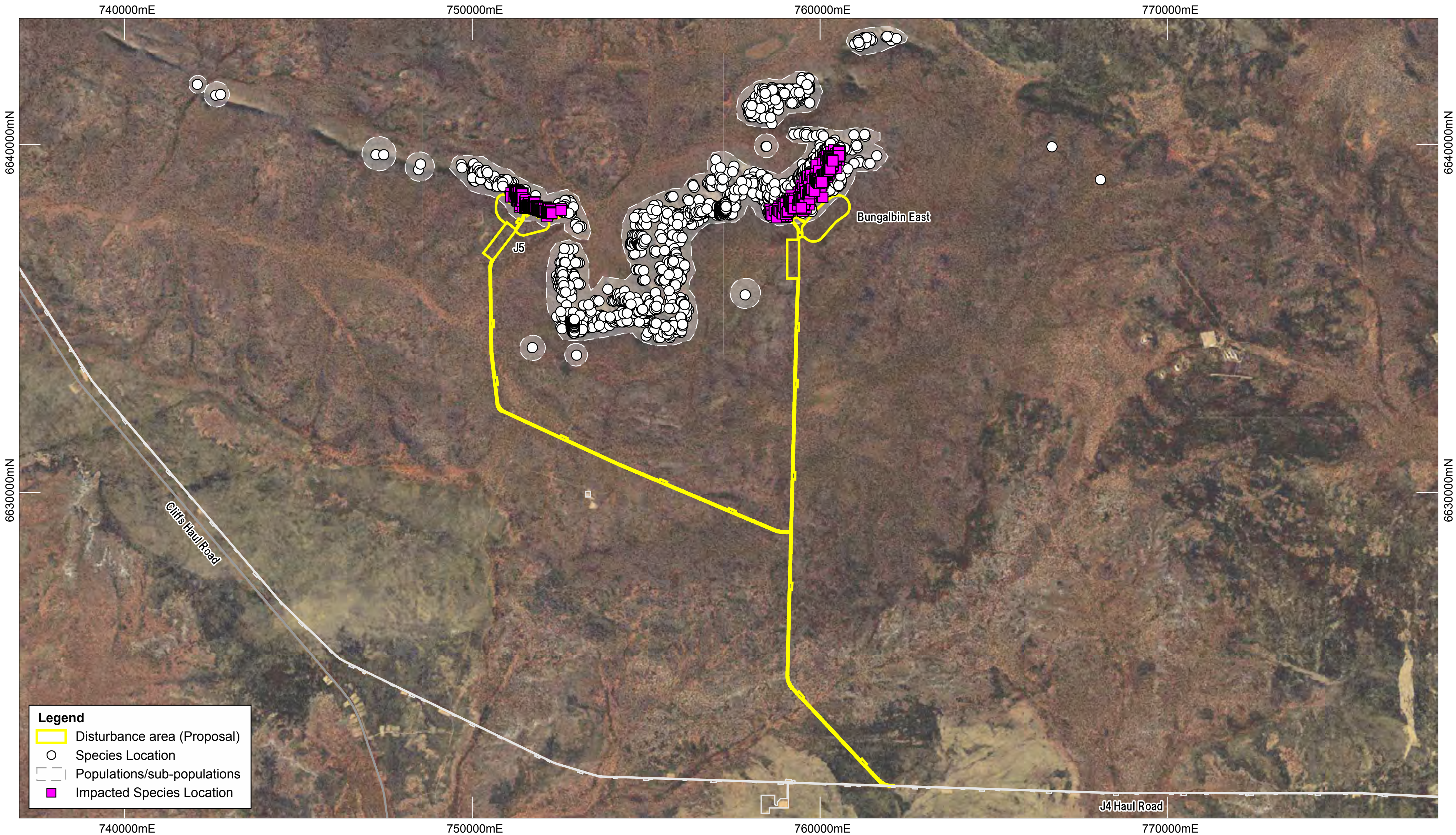
IMPACT ON *STENANTHEMUM NEWBEYI* (P3)

Figure: **5-21**



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Prioirty species supplied by Ecologia, Mattiske Consulting Pty Ltd & DPaW
Imagery: U.S. Geological Survey (2016)
Populations/sub-populations by Woodman Environmental Consulting Pty Ltd

0 1.5 3km
Scale 1:150,000
MGA94 (Zone 50)

CAD Ref: g2313_J5_BE_PER_C05_F05_25
Date: July 2016 | Rev: D | A4

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IMPACT ON
***BANKSIA ARBOREA* (P4)**

Figure:
5-22

TABLE 5-11: DIRECT IMPACTS ON P3 AND P4 PRIORITY FLORA

Taxon	Code	Plants Surveyed[1]			Plants Cleared			Total plants remaining[2]	Proposal Disturbance	
		MRL	CAPIO	TOTAL	MRL	CAPIO	TOTAL		No. of plants	%
Grevillea georgeana	P3	7445	6,435	13,808	2	119	121	13,687	1,023	7.5
Hibbertia lepidocalyx subsp. *tuberculata*	P3	48,364	44,133	92,497	0	1,126	1,126	91,371	5,856	6.4
Lepidosperma ferricola	P3	33,438	66,598	100,036	0	8,425	8,425	91,611	25	0.0
Mirbelia ferricola	P3	12,080	0	12,080	0	0	0	12,080	769	6.4
Neurachne annularis	P3	1,415,485	0	1,415,485	103,659	0	103,659	1,311,826	25,440	1.9
Stenanthemum newbeyi	P3	90,449	29,893	120,342	0	5,132	5,132	115,210	13,042	11.3
Banksia arborea	P4	18,688	10,031	28,719	599	861	1,460	27,259	4,965	18.2
Eucalyptus formanii	P4	620	10,814	11,434	0	774	774	10,660	260	2.4
Grevillea erectiloba	P4	1,185	3,067	4,252	1	2	3	4,249	110	2.6

[1] Includes MRL survey data associated with Carina, Carina Extended, Chameleon, J4, J5 and Bungalbin East deposits as well as CAPIO survey data associated with Koolyanobbing, Jackson and Windarling Ranges.

[2] Includes all CAPIO plants remaining at Koolyanobbing, Jackson and Windarling Ranges as at 2015/11 aerial pickup

Bioscope Environmental (**Appendix 5-F**) considered the potential impact on the conservation status of B. *arborea* and concluded that an increase of Priority status currently ascribed to this taxon is unlikely, and it follows that the taxon will not be considered for listing under the WC Act. For S. *newbeyi*, if the Proposal was implemented, more than 10,000 plants would remain within the study area. No change to the conservation status of the other Priority taxa is expected.

The extent to which P3 and P4 taxa potentially impacted by the Proposal are represented within conservation tenure is addressed in **Table 5-12**. Data from outside the study area represents known data only and is not the result of a comprehensive survey effort; however, based on the known data, all but two of the taxa listed in **Table 5-12** are well represented in reserves or proposed reserves with at least 10,000 plants. The exceptions are *Eucalyptus formanii* and *Grevillea erectiloba*; however in both cases the majority of known plants occur within reserves or proposed reserves.

TABLE 5-12: REPRESENTATION OF P3 AND P4 FLORA

Taxon	Code	Total known no. of plants	No. within MMHARCP	No. within Mount Manning Range Nature Reserve	No. within proposed reserves[1]	No. outside of reserves and proposed reserves
Grevillea georgeana	P3	13,687	6,296	1	7,458	4
Hibbertia lepidocalyx subsp. *tuberculata*	P3	91,371	47,403	-	814	43,020
Lepidosperma ferricola	P3	91,611	33,448	-	502	57,661
Mirbelia ferricola	P3	12,080	12,005	-	60	15
Neurachne annularis	P3	1,311,826	1,071,647	-	4,986	112,376
Stenanthemum newbeyi	P3	115,210	89,453	-	3,875	21,865
Banksia arborea	P4	27,259	17,766	40	3,317	6,168
Eucalyptus formanii	P4	10,660	1,316	420	4,148	4,711
Grevillea erectiloba	P4	4,249	1,493	-	2,372	387

[1] Note: Proposed reserves include all or parts of the Jaurdi and Mt Jackson Pastoral Stations, currently managed by DPaW

Almost all Priority Flora recorded in surveys for this Proposal have all or almost all (close to 100 %) of their populations occurring within the MMHARCP although mining tenure (mining leases, mining lease applications or exploration licences) co-occurs.

Exceptions include:

- *Grevillea georgeana* (P3) – about 79 % of known plants occur in conservation tenure with the remainder in proposed conservation tenure.
- *Neurachne annularis* (P3) – about 82 % of known plants occur in conservation tenure with almost all of the remainder on Unallocated Crown Land (UCL).
- *Eucalyptus formanii* (P4) - about 78 % of known plants occur in conservation tenure, 8 % in proposed conservation tenure and 13 % on UCL.

In summary, MRL makes the following observations about the potential direct impacts on individual taxa:

- Removal of individuals of T. *aphylla* subsp. *aphylla* and L. *spectabilis* from within the Proposal disturbance area is not expected to warrant a higher IUCN threat level as a result of the implementation of the Proposal.
- With the provision of comprehensive survey data, the conservation status of L. *bungalbin* may be reviewed.
- Potential direct impacts on T. *aphylla* subsp. *aphylla* and L. *bungalbin* are significant based on the proportion of known plants which would be removed (28.5 % and 39.3 % respectively) although many plants would remain outside of the disturbance area (over 60,000 plants and 27,000 plants respectively).

Potential impacts on L. *spectabilis* and Priority species other than L. *bungalbin* are not significant.

Vegetation

Over 30,000 ha of vegetation were mapped by ecologia Environment to support the impact assessment for the Proposal. When other available mapping outside of the study area is included (see **Section 5.2.1**), the total area mapped exceeds 80,000 ha. There is therefore a good understanding of the extent and distribution of vegetation associated with the Proposal and elsewhere in the study area.

Of the 45 vegetation units mapped by ecologia Environment, clearing of 2 % or more is proposed for nine units (**Table 5-13**). Seven of the nine vegetation units form part of the PSRN supergroup and are associated with the HAR PEC. The most extensive impacts occur within the disturbance area of the Bungalbin East mine pit. PSRN6 and PSRN7 both have an extent of less than 100 ha with 37.2 % and 31.2 % respectively occurring within the proposed disturbance area. With the exception of PSRN23 (12.1 %), the other six vegetation units listed in **Table 5-13** have an extent of well under 10 % within the proposal disturbance area.

When all vegetation units are combined into supergroups, the impact of land clearing on the PSRN supergroup relative to other supergroups is apparent (**Table 5-14**). The potential impact on the PSRN supergroup is greatest, both as a proportion of vegetation mapped (2.3 %) and in total hectares (261.3 ha).

In considering the HAR PEC, 6.3 % of the area defined by DPaW will be affected by land clearing under this Proposal (**Figure 5-23, Figure 5-24**). When compared with the Proposal disturbance area, the impact on the PEC analogue defined by ecologia Environment is 4.7 %. Note that at 4.7 %, it is greater than the 2.3 % identified as the impact on the PSRN supergroup because the latter includes occurrences of PSRN vegetation units outside of the HAR PEC.

TABLE 5-13: EXTENT OF PROPOSED LAND CLEARING ON VEGETATION UNITS

Code	Total mapped in Study Area (ha)	Proposed clearing (ha)	% of total mapped[1]	Component of PEC analogue	Comments
MIPL1	559.1	12.1	2.2	No	Occurs within Bungalbin East infrastructure area.
PNC3	3,689.6	153.2	4.2	No	Occurs around the base of ridges and is the main vegetation unit affected by the proposed waste rock landform disturbance areas at both sites.
PSRN0	1073.0	84.1	7.8	Yes	Occurs along ridges within the study area. Most common vegetation unit within the proposed Bungalbin East open pit disturbance area.
PSRN1	1,426.5	73.2	5.1	Yes	Occurs within both open pit disturbance areas and the waste rock landform disturbance area at Bungalbin East.
PSRN6	60.1	22.4	37.2	Yes	Occurs within the disturbance areas of both open pits but also at Bungalbin Hill.
PSRN7	47.3	14.7	31.2	Yes	Primarily occurs at the northern end of the proposed Bungalbin East open pit.
PSRN18	135.6	5.2	3.9	Yes	Occurs at J5, partially within the waste rock landform disturbance area.
PSRN21	668.3	35.4	5.3	Yes	Occurs along ridges within the study area. Most common vegetation unit within the proposed J5 open pit disturbance area.
PSRN23	85.4	10.3	12.1	Yes	Occurs within the proposed Bungalbin East open pit and to the north and south of the ridge. Important unit for *Lepidosperma bungalbin*.

[1] Only impacts ≥ 2% shown.

TABLE 5-14: DIRECT IMPACT ON VEGETATION SUPERGROUPS

Code	Total mapped in Study Area (ha)	Total mapped outside of Study Area (ha)	Total mapped (ha)	Proposed clearing (ha)[1]	% of total mapped
PCS	12,547.1	16,788.4	29,335.5	151.5	0.5
PNC	7,155.1	7,730.6	14,885.7	166.0	1.1
MIPL	744.7	3,267.5	4,012.2	12.1	0.3
MISP	1,702.9	3,197.1	4,899.9	2.1	0.0
PSRN	7,518.6	3,931.3	11,449.9	261.3	2.3
RSWN	26.9	898.8	925.6	0.0	0.0
SPAC	1,615.1	5,739.8	7,355	3.7	0.1
SPAB	369.5	10,258.7	10,628.2	9.7	0.1
Total	31,679.9	51,812.2	83,492.0	606.4	0.7

[1] Note: Due to rounding, this amount differs slightly from the 611 ha given as the Proposal disturbance area.

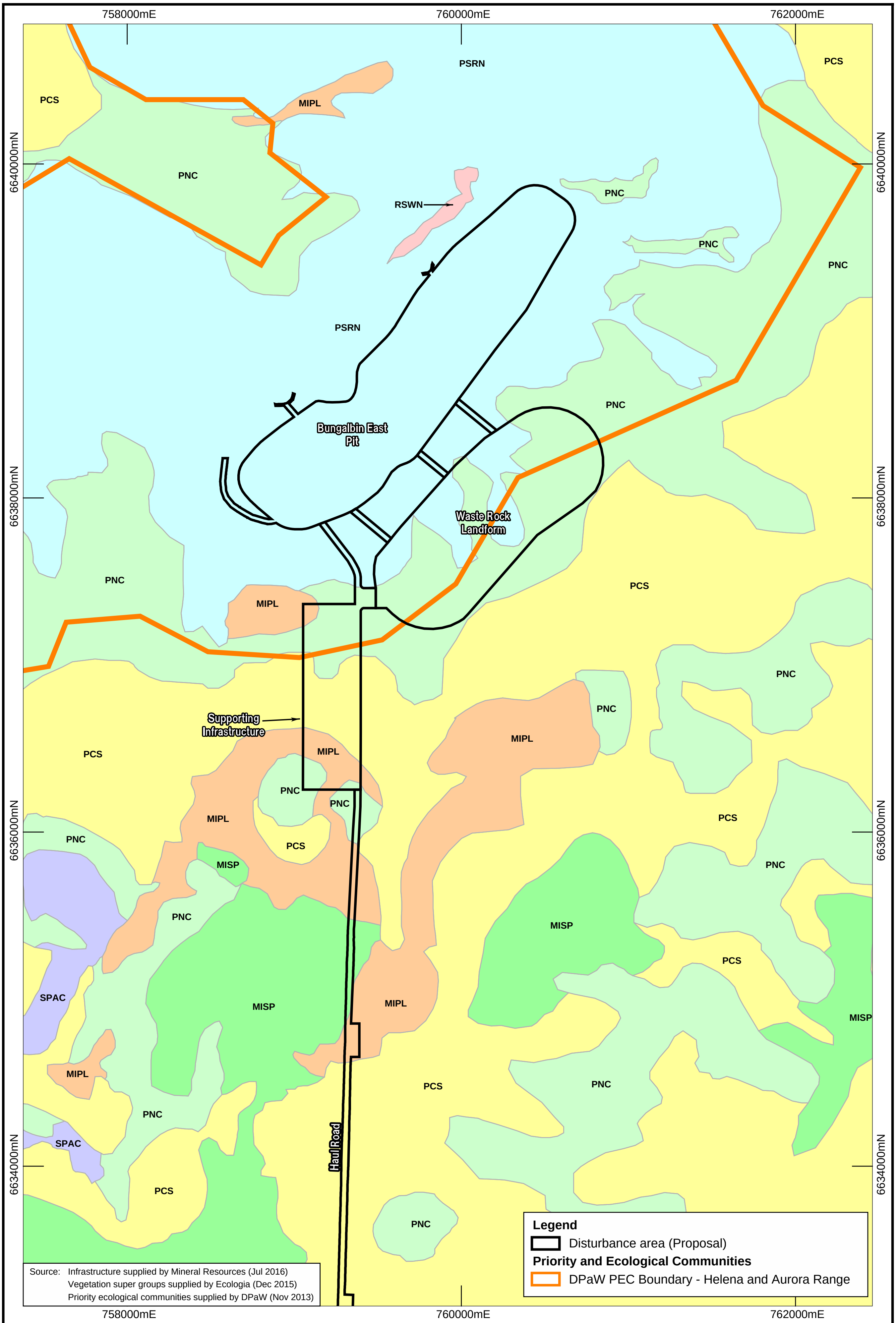
TABLE 5-15: DIRECT IMPACT ON PRIORITY ECOLOGICAL COMMUNITY

PEC boundary	Total area (ha)	Proposed clearing (ha)	% of total
As determined by DPaW	5,573.6	352.3	6.3
PEC analogue determined by ecologia based on vegetation mapping (vegetation units PSRN0, PSRN1, PSRN2, PSRN6, PSRN7, PSRN14, PSRN17, PSRN18, PSRN20, PSRN21, PSRN22, PSRN23 and PSRN24).	5,232.0	248.3	4.7

Almost all of the HAR PEC and the PEC analogue based on ecologia Environment's vegetation mapping are contained within the MMHARCP (**Table 5-16**). One small part of the western end of the PEC, about 2.5 % of the total PEC area, occurs on Unallocated Crown Land (UCL). Across the PEC there is relatively little existing disturbance (primarily exploration tracks). Overall, over 90 % of the PEC and PEC analogue would be retained following implementation of the Proposal.

The extent of the impact of the Proposal on vegetation can be summarised as follows:

- A total of 349.2 ha (6.3 %) of the HAR PEC (Priority 1) will be removed.
- A total of 248.3 ha (4.7 %) of the PEC analogue defined by ecologia Environment will be removed.
- Proportions greater than 10 % (12.1-37.2 %) of individual vegetation units (PSRN6, PSRN7 and PSRN23) will be removed. Conservation-significant taxa are strongly represented within these vegetation units.
- Almost all of the PEC and PEC analogue is contained within the MMHARCP of which over 90 % would be retained if the Proposal proceeds.



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0 300 600m

Scale 1:30,000

MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C05_F05_07

Date: July 2016 | Rev: F | A4

MINERAL RESOURCES

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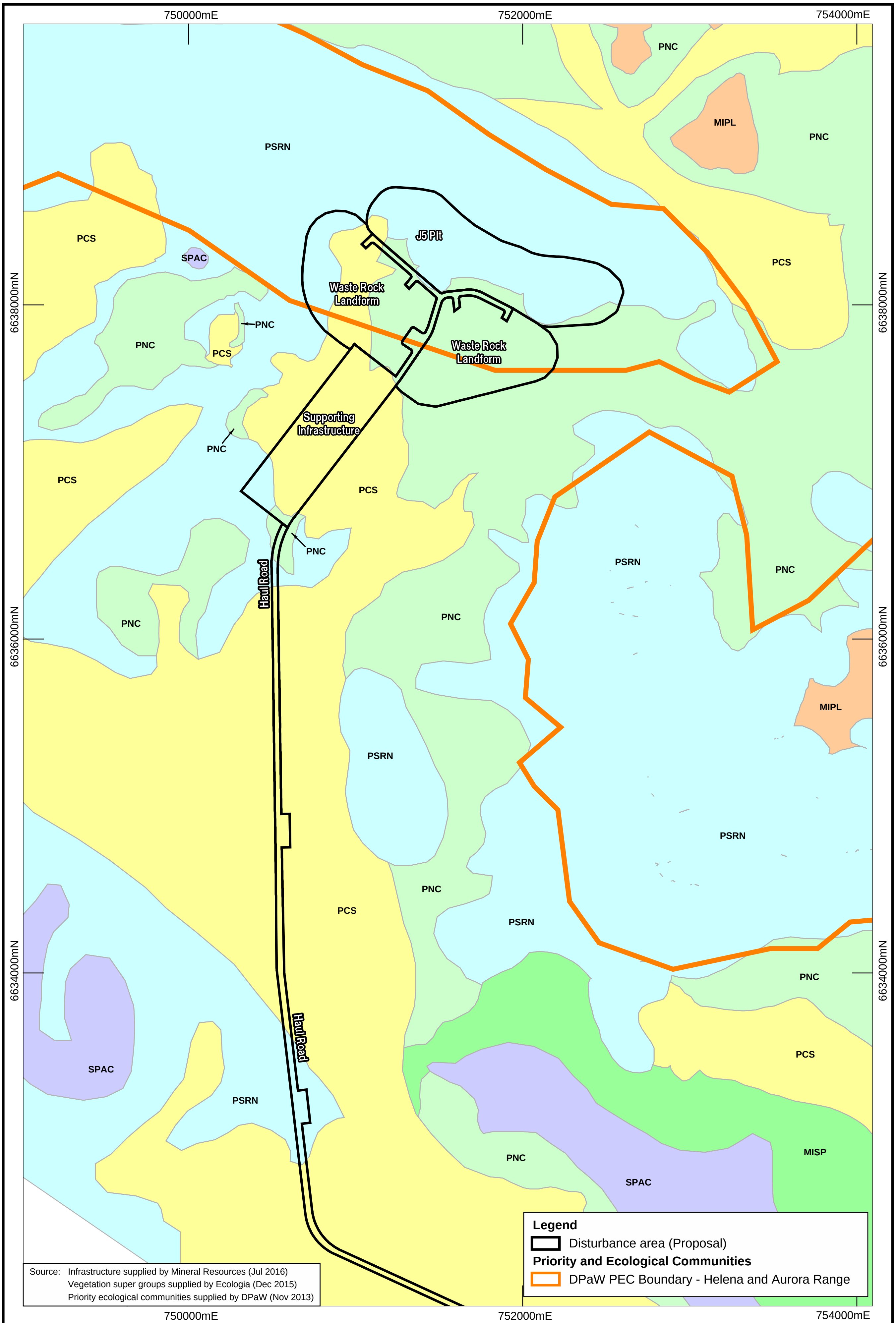
BUNGALBIN EAST- IMPACT ON PEC AND VEGETATION SUPERGROUP

Figure:

5-23



J5 - IMPACT ON PEC AND VEGETATION SUPERGROUPS

Figure: 5-24

TABLE 5-16: EXTENT OF HIGH VALUE VEGETATION WITHIN THE MMHARCP

Vegetation	Total area (ha)	Area within MMHARCP (ha) (% of total)
Helena and Aurora Range vegetation complexes (banded ironstone formation) PEC (as determined by DPaW)	5,573.6	5,430.1 (97.4 %)
PEC analogue (as determined by ecologia Environment based on vegetation units PSRN0, PSRN1, PSRN2, PSRN6, PSRN7, PSRN14, PSRN17, PSRN18, PSRN20, PSRN21, PSRN22, PSRN23 and PSRN24).	5,336.8	5,179.5 (97.1 %)

5.3.1 Potential indirect impacts

This section discusses potential indirect impacts, that is, potential impacts occurring outside of areas for which land clearing will be necessary to implement this Proposal. In considering the potential for indirect impacts, MRL has adopted a conservative approach as will be described in the subsequent section.

Foliar dust deposition

Establishment of an operational mine can lead to sources of dust that include:

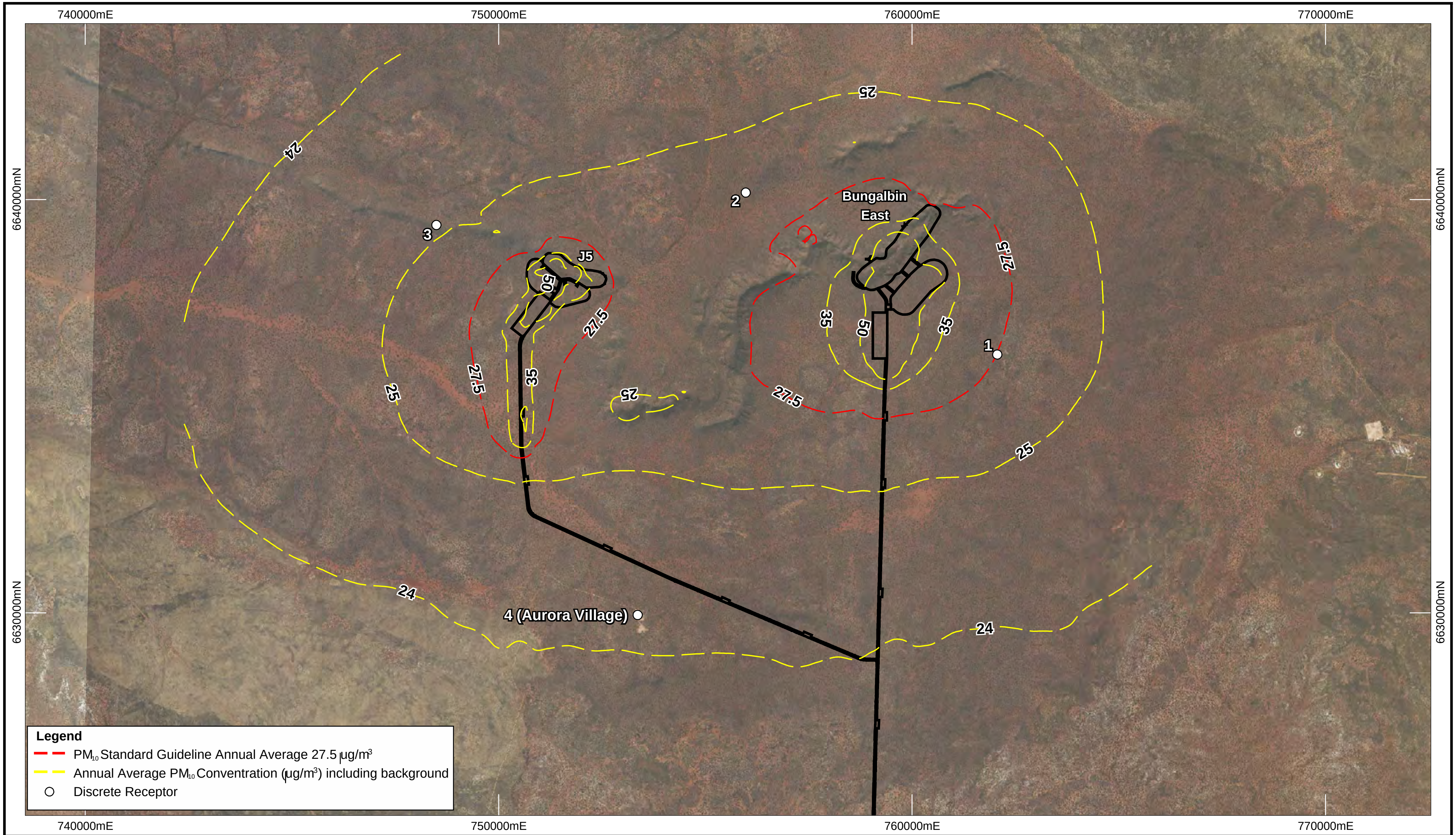
- blasting operations
- excavation, loading and haulage of mined materials
- wheel-generated dust from vehicles
- wind-blown dust from disturbed, open areas and structures such as product or topsoil stockpiles

Pacific Environment Ltd undertook modelling of air quality which is discussed in detail in Section 10. Its emission estimates for particulate matter < 10 $\mu m/m^3$ (PM_{10}) identified loading and unloading of ore and waste rock as the primary activity contributing to the overall dust load during mine operations. The estimated annual average PM10 concentrations around Bungalbin East and J5 during operations are shown in **Figure 5-25**. Values in immediate proximity to the pits are in the 35-50 $\mu m/m^3$ PM_{10} range.

Monitoring undertaken by Cliffs Asia Pacific Iron Ore in relation to the Windarling operations (Cliffs Asia Pacific Iron Ore Pty Ltd, 2014; 2015b) between 2003 and 2014 recorded higher dust levels on vegetation close to open pit operations than at locations further away. However, the company did not record any difference in the health of threatened flora occurring close to open pits compared with control plants further away. Cliffs' monitoring indicated that rainfall was the key determinant of plant condition.

Similarly, Matsuki et al. (2016) note that a comparable response to that occurring at Windarling was also recorded at Barrow Island under conditions where deposited dust was much higher (up to 77 g/m^2/month) than that at Windarling (up to 20 g/m^2/month). An earlier assessment of impacts on plants at Windarling using a smaller data set (Yates & Williams, 2005) recorded an increase in mortality and a decline in plant condition in proximity to the mine. However, this study included some plants approved for clearing (Cliffs Asia Pacific Iron Ore Pty Ltd. pers. comm.) thus did not necessarily reflect 'indirect' impacts.

On this basis, the potential impact from foliar dust deposition on high value flora and vegetation is likely to be minimal and restricted to areas immediately adjacent to the open pits but may also occur adjacent to other areas such as stockpiles, haul roads and waste rock landforms.



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: Landgate (2012)
Air quality data supplied by Pacific Environment Limited (Jan 2016)

CAD Ref: g2313_J5_BE_PER_C05_F05_13
Date: July 2016 | Rev: D | A4

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ANNUAL AVG PM10 CONCENTRATIONS (INC BACKGROUND VALUES)

Figure: 5-25

Fragmentation and changes to microhabitats

In addition to overall disturbance, the viability of plant communities and flora remaining after land clearing may be reduced by fragmentation. Fragmentation could lead to localised changes in microclimate (temperature, wind, and light) which could degrade communities and individual plants. Consideration of the potential impacts on four taxa - *Leucopogon spectabilis*, *Tetratheca aphylla* subsp. *aphylla*, *Acacia adinophylla* and *Lepidosperma bungalbin* - in populations adjacent to the proposed land clearing and mining is provided in **Table 5-17**. These four taxa are those with the highest conservation significance and on which direct impacts are expected.

Based on their distribution relative to the proposed disturbance, there is some potential for impacts due to changes in microclimate in three of four key species where plants exist immediately adjacent to the Proposal area. However, given the inclusion of buffer areas when assessing direct impacts, and the experience at Windarling as discussed above, the potential for impacts beyond those already assessed in this document is low.

TABLE 5-17: POTENTIAL INDIRECT IMPACTS ON KEY TAXA

Species	Code	Figure	Comments
Leucopogon spectabilis	T	**Figure 5-12** **Figure 5-13**	No potential impact – the most substantial part of the population occurs more than a kilometre from the proposed Bungalbin East open pit.
Tetratheca aphylla subsp. *aphylla*	T	**Figure 5-14** **Figure 5-15**	Some potential impact. Plants will occur at or near to the pit edge at Bungalbin East.
Acacia adinophylla	P1	**Figure 5-16** **Figure 5-17** **Figure 5-18**	Some potential impact. Plants will occur at or near to the pit edge at and waste rock landforms at both Bungalbin East and J5.
Lepidosperma bungalbin	P1	**Figure 5-19** **Figure 5-20**	Some potential impact. Plants will occur at or near to the pit edge at Bungalbin East.

Impacts to ecosystem processes

While some plants will be removed directly to enable establishment of the operations, adjacent vegetation should remain intact with little or no disturbance, allowing ecosystem processes to continue.

These processes include pollination and seed dispersal. While specific data for key taxa is not available, a review of available literature (**Table 5-18**) indicates that L. *spectabilis* and T. *aphylla* subsp. *aphylla* are bee-pollinated. A. *adinophylla* is also likely to be insect-pollinated while L. *bungalbin* is wind-pollinated. There is some potential for these processes to be disrupted immediately adjacent to active mine areas but impacts should extend no more than a few metres into established vegetation.

With regard to seed dispersal, the likely vectors are ants and birds (**Table 5-19**). As for pollination, there is some potential for seed dispersal to be affected immediately adjacent to active mine areas but impacts should extend no more than a few metres into established vegetation.

Other ecosystem processes such as nutrient cycling and nitrogen fixation should be undiminished in areas where direct impacts have not occurred.

TABLE 5-18: LIKELY POLLINATION VECTORS FOR KEY TAXA

Species	Code	Likely Vector	Comments
Leucopogon spectabilis	T	Native bees	Little is known about the biology of *L. spectabilis*, with the Interim Recovery Plan (Department of Environment and Conservation, 2010) proposing investigation of pollination biology and determination of reproductive strategies, amongst other biological and ecological investigations. Based on limited available information at genus level, it is considered likely that *L. spectabilis* is pollinated by insects. Keighery (1996) notes that species of *Leucopogon* have relatively unspecialised flowers; it is considered that *L. spectabilis* conforms to this assessment, based on the description of its flowers (Hislop & Chapman, 2007). Keighery (1996) observed that *L. australis* flowers were pollinated by bees, moths, butterflies and flies. Given that *L. spectabilis* is considered to be relatively closely related to *L. australis* (Hislop & Chapman, 2007), it is considered likely that *L. spectabilis* is also pollinated by one or a combination of the aforementioned insect groups; bees are considered to be the most likely primary pollinator (Keighery, 1996). Further investigation is required to confirm the specific pollinators of this species.
Tetratheca aphylla subsp. aphylla	T	Native bees	*T. aphylla* subsp. *aphylla* is likely to be predominantly pollinated by native bees (Yates, et al., 2008), via a process referred to as 'buzz pollination' (Fidalgo & Kleinert, 2009). *Tetratheca* flowers do not produce nectar (Yates, et al., 2008), however are known to produce a sweet musky scent (Alford, 1990; Butcher, et al., 2007a). This may serve to attract pollinators to the flowers (Alford, 1990) including native bees, which seek out pollen as a food source. The pollen is held within anthers arranged in a ring around the style (Yates, et al., 2008), and is discharged from each via a terminal pore (Thompson, 1976). Native bees extract the pollen by sonicating ('buzzing') pollen loose from the anthers, or alternatively by raking the anthers with their front legs (Yates, et al., 2008). The bees may then transfer the collected pollen to other flowers inadvertently when they come in to contact with the stigma, which protrudes above the anthers when receptive (Yates, et al., 2008). Three species of native bee from the genus *Lasioglossum* and four unidentified native bee species have been observed foraging on flowers of *Tetratheca* species that occur on BIF ridges in the Yilgarn region (Yates *et al.* 2008), however it is unknown which specific species have been recorded foraging on flowers of *T. aphylla* subsp. *aphylla*.

Species	Code	Likely Vector	Comments
Acacia adinophylla	P1	Insects	Although little is known about the specific biology of *Acacia adinophylla*, the biology of Australian *Acacia* is relatively well-known, and is considered applicable to *Acacia adinophylla* in a broad sense. The flowers of most *Acacia* species, including *A. adinophylla*, are reduced and lack nectar (Tybirk, 1997). However, they produce odour and have strongly exserted stamens, and are aggregated in a dense inflorescence, whose surface consists of the exserted stamens (Tybirk, 1997). The odour is considered to attract pollinators, with the dense inflorescence providing a source of easily accessible, protein-rich pollen as a reward (Tybirk, 1997; Kodela, et al., 2012). Due to the ease of accessibility of the pollen, no specialised technique is required for a collection. Basic *Acacia* pollination is therefore considered to be unspecialised insect pollination, however bird pollination has also developed in some Australian species such as A. *pycnantha* (Tybirk, 1997; Kodela, et al., 2012). A variety of generalist insect species have been implicated (Tybirk, 1997), with pollinators mostly involved being beetles, wasps and bees (Kodela, et al., 2012). It is considered that species of these insect groups are the likely pollinators of A. *adinophylla*.
Lepidosperma bungalbin	P1	Wind	Barrett (2013) undertook a review of all Australian *Lepidosperma* species, including L. *bungalbin*. He concluded that all species are wind-pollinated.

TABLE 5-19: LIKELY SEED DISPERSAL VECTORS FOR KEY TAXA

Species	Code	Likely Vector	Comments
Leucopogon spectabilis	T	Birds and other animals	Based on limited available information at genus level, it is considered likely that the seeds of *L. spectabilis* are dispersed by animals. L. *spectabilis* fruits are fleshy drupes (Hislop & Chapman, 2007); the fruits of the relatively closely-related *L. australis* have been observed to be fed upon by two small bird species, and in the faeces of emus (Keighery, 1996). Observations in eastern Australia indicate that the seeds of *Leucopogon* and other members of the Ericaceae family are likely to survive ingestion by birds (Ford (1986) in Keighery (1996). It is therefore likely that *L. australis* is primarily dispersed by birds; other potential dispersal agents may include ants, reptiles and mammals (Keighery, 1996). Given this, *L. spectabilis* may therefore also be dispersed in a similar way.

Species	Code	Likely Vector	Comments
Tetratheca aphylla subsp. *aphylla*	T	Ants	It is considered likely that the seeds of *Tetratheca,* including *T. aphylla* subsp. *aphylla*, are dispersed by ants, a process known as myrmecochory (Berg, 1975). *Tetratheca* seeds, including *T. aphylla* subsp. *aphylla*, possess a prominent elaiosome, a lipid-rich structure used as a food source for ants (Mayer, et al., 2005). The ants remove the entire seed, including the elaiosome, to their nest, where the elaiosome is consumed; seed is then usually abandoned intact in the nest or just outside on waste piles (Mayer, et al., 2005). Although this process has not been directly observed for *T. aphylla* subsp. *aphylla*, seeds of the related and geographically and ecologically close species *Tetratheca paynterae* subsp. *payneterae* have been observed being removed by three species of ants from experimental cafeterias (Yates and Dillon unpublished data, in Portman Iron Ore Pty Ltd / CALM (2006).
Acacia adinophylla	P1	Ants	Acacia seeds, including those of *Acacia adinophylla,* are initially dispersed via ejection from the pod, usually under the influence of hot sun (Kodela, et al., 2012). However, *Acacia adinophylla*, as for many Australian *Acacia* species, also has seeds with a conspicuous aril (Maslin, 1999). The aril functions as an elaiosome, and therefore such seeds are likely dispersed via myrmecochory (Kodela, et al., 2012), as discussed for *Tetratheca aphylla* subsp. *aphylla*.
Lepidosperma bungalbin	P1	Ants and/or birds	According to Barrett (2013), all Australian *Lepidosperma* species, including *L. bungalbin*, produce a nutlet (a fruit that contains a single seed) that has persistent hypogynous scales at its base (Barrett 2013); these scales function as an elaiosome (Berg, 1975). Dispersal of nutlets that fall from the inflorescence is therefore via ants. However, birds also remove nutlets directly from the inflorescence, and therefore act as dispersal agents in both local and long-distance contexts (Barrett, 2013).

Introduction and/or spread of weeds

Environmental weeds can compete for resources with native flora and disrupt ecological functions. When intact populations of native plants are fragmented, the risk of weed incursion increases. Weed numbers and cover can increase by:

- Windblown seed from existing weed populations spreading to adjoining areas
- Weed seed in existing seed banks being spread during soil movement or disturbance; and
- Weed seed entering the site through contaminated vehicles, earthmoving equipment or construction materials.

Given that surveys identified a low inherent weed cover, the risk of weed introduction primarily lies with the inadvertent introduction of weed seed to the site. Additionally, increases in weed cover may occur through disturbance of soils which promote germination of existing weed seed banks allowing local increases in weed populations. This risk can be readily reduced through the application of routine weed monitoring and hygiene/treatment procedures applied to vehicle and equipment movements.

Alteration of surface water flows

With respect to flora and vegetation and the alteration of surface water flows, there are no major flow lines directly intersecting either of the open pits, the waste rock landforms or supporting infrastructure areas. Most of the main work areas are located either on top of the ridgeline (i.e. the open pits) or on the lower slopes adjacent to the ridge line (i.e. the waste rock landforms). This means that there is essentially no catchment area upslope from these work areas, and therefore little-to-no surface runoff is expected to flow into these areas from up-slope. While some works will be required to manage surface water (see **Section 9**), no significant impact is expected on flora and vegetation. Flora and vegetation surveys (**Appendix 5-A**) did not record any sheet flow-dependent vegetation.

Changes to fire regime

While BIF ridges and other elevated areas may attract lightning strikes, surveys undertaken for this assessment indicate that fire is not a frequent occurrence (**Table 5-7**). However MRL Emergency Services from Carina mine site have responded to protect infrastructure from at least two natural bush fires since 2010. The presence of the mining operations introduces further potential sources of fire. As the response to fire in many of the taxa recorded in surveys is unclear, maintenance of a 'natural', infrequent fire regime will be the aim of management measures. To date, there have been no fire incidents generated from MRL mining activities in the region.

Fly and rill rock

Blasting prior to mining has the potential to result in fly or rill rock – rock that leaves the blast zone when a blast occurs. Fly or rill rock can damage vegetation and fauna habitat. Fly rock is usually caused by a lack of confinement of the explosive in the ground through insufficient stemming heights, incorrect stemming material selection, blast sequence issues or defects in the rock mass.

Grazing by stock or feral animals

Goats are known to occur on rocky or hilly country in semi-arid rangelands but were not recorded in fauna surveys for this Proposal (see **Section 8**). For a goat population to establish within the Proposal area, a permanent water source would need to be established. While water will be available during operations, the Proposal does not involve the establishment of any permanent water sources, such as a pit lake. All mining will be above the groundwater table and no water holding facilities will remain after closure.

Rabbits were recorded in surveys (see **Section 8**), including within the PSRN20 vegetation unit. A continued presence is expected to occur during and after operations, should this Proposal proceed but should not increase as a result of the Proposal.

No other feral species likely to cause significant grazing pressure occurs in the Proposal area.

5.3.2 Summary of direct and indirect impacts

Direct impacts on flora and vegetation will occur when land clearing is undertaken to establish the mine and related infrastructure. Indirect impacts, as described in **Section 0**may also occur but, given the conservative approach to the assessment, actual indirect impacts are likely to be less than that predicted.

To take account of the potential indirect impacts, MRL has applied a 20 m buffer of the open mine pits, waste rock landforms and supporting infrastructure. While MRL considers that indirect impacts can be avoided (see **Section 5.4.2**), for impact assessment purposes it can be conservatively assume that flora and vegetation occurring within the buffer will be lost.

On the conservative assumption that all flora and vegetation will be lost within the buffer, the total potential direct and indirect impact on each taxon is outlined in **Table 5-20** to **Table 5-22**. The total potential direct and indirect impact on vegetation units, supergroups, HAR PEC and PEC analogue is provided in **Table 5-23** to **Table 5-25**.

TABLE 5-20: SUMMARY OF POTENTIAL IMPACTS ON THREATENED FLORA

Taxon	Total no. of plants recorded	No. of plants within mine disturbance area	No. of plants within 20 m buffer	Proposed impact (%) – direct and indirect
Leucopogon spectabilis (Ironstone Beard-heath)	14,434	130	0	0.9
Tetratheca aphylla subsp. *aphylla* (Bungalbin Tetratheca)	87,921	25,069	818	29.4

TABLE 5-21: SUMMARY OF POTENTIAL IMPACTS ON P1 PRIORITY FLORA

Taxon	Total no. of plants recorded	No. of plants within mine disturbance area	No. of plants within 20 m buffer	Proposed impact (%) – direct and indirect
Acacia adinophylla	10,529	1,194	103	12.3
Acacia shapelleae	1,320	16	0	1.2
Beyeria rostellata	568	0	0	0.0
Lepidosperma bungalbin	45,976	18,046	187	39.7

TABLE 5-22: SUMMARY OF POTENTIAL IMPACTS ON P3 AND P4 PRIORITY FLORA

Taxon	Code	Total known no. of plants	No. of plants within Proposal disturbance area	No. of plants within 20 m buffer	Proposed impact (%) – direct and indirect
Grevillea georgeana	P3	13,688	982	41	7.5
Hibbertia lepidocalyx subsp. tuberculata	P3	91,271	5,519	337	6.4
Lepidosperma ferricola	P3	9,611	15	10	0.3
Mirbelia ferricola	P3	12,080	746	20	6.3
Neurachne annularis	P3	1,316,776	25,336	104	1.9
Stenanthemum newbeyi	P3	115,210	12,428	614	11.3
Banksia arborea	P4	27,291	4,965	165	18.8
Eucalyptus formanii	P4	10,648	240	20	2.4
Grevillea erectiloba	P4	4,249	105	5	2.6

TABLE 5-23: SUMMARY OF POTENTIAL IMPACTS ON VEGETATION UNITS

Vegetation Unit[1]	Total mapped in Study Area (ha)	Proposed clearing (ha)	Extent of vegetation unit in 20 m buffer	Proposed impact (%) – direct and indirect
MIPL1	559.12	12.07	0	2.2
PNC3	3689.61	153.17	9.96	4.4
PSRN0	1073.0	84.1	7.08	8.5
PSRN1	1426.5	73.18	10.88	5.9
PSRN6	60.09	22.35	0	37.2
PSRN7	47.26	14.74	2.43	36.3
PSRN18	135.56	5.24	0	3.9
PSRN21	668.34	35.41	4.63	6.0
PSRN23	85.43	10.32	0.68	12.9

[1] Only units with impacts ≥ 2% shown

TABLE 5-24: SUMMARY OF POTENTIAL IMPACTS ON VEGETATION SUPERGROUPS

Vegetation Supergroup	Total mapped (ha)	Proposed clearing (ha)	Extent of supergroup in 20 m buffer zone (ha)	Potential direct and indirect impacts as % of total mapped
PCS	29335.5	151.5	6.2	0.5
PNC	14885.7	166	12	1.1
MIPL	4012.2	12.1	1.3	0.3
MISP	4899.9	2.1	0	0
PSRN	11,449.9	261.3	29	2.3
RSWN	925.6	0	0	0
SPAC	7355	3.7	0	0.1
SPAB	10628.2	9.7	0	0.1

TABLE 5-25: SUMMARY OF POTENTIAL IMPACTS ON HAR PEC

PEC boundary	Total area (ha)	Proposed clearing (ha)	Extent of PEC or PEC analogue in 20 m buffer zone (ha)	Potential direct and indirect impacts as % of total mapped
As determined by DPaW	5573.6	352.3	33.1	6.9
PEC analogue (PSRN0,1,2,6,7,14,17,18,20,21, 22,23,24).	5232.0	248.3	29.0	5.3

5.4 Environmental management

5.4.1 Review of past management practices

Woodman Environmental conducted a review of MRL's past and current management of threatened and other conservation-significant flora and communities (**Appendix 5-G**). The review concluded that:

- MRL has no historical experience in rehabilitation and restoration associated with conversation-significant flora and communities
- MRL's operations at Carina and J4 have demonstrated effective management of impacts to conservation-significant flora and communities. Both operations have approvals under Part IV of the EP Act. In its most recent Compliance Assessment Report (Polaris Metals, 2016a), the Carina operation recorded compliance with conditions relating to conservation-significant vegetation. Similarly, the most recent compliance assessment report for J4 (Polaris Metals, 2016b) recorded compliance with conditions relating to avoidance of conservation-significant flora and vegetation in the establishment of a haul road
- MRL is a partner in an Australian Research Council (ARC) project aimed at contributing to training and research into mine site restoration techniques. The ARC

Industrial Transformation Training Centre (ITTC) for Mining Restoration commenced in 2015

- MRL has an EMS and is proposing accreditation to the ISO14001 standard for the J5 and Bungalbin East Proposal.

With regard to MRL's corporate experience, MRL has not previously sought approvals to mine in an environment where rehabilitation and restoration of threatened and conversation-significant flora and communities was a requirement. However, MRL employees have experience in this area and also experience in mine rehabilitation planning and implementation. MRL also has access to extensive experience within consultancies, universities and contracting companies, some of whom provided input to this PER (see **Section 1.8**).

Woodman Environmental also noted that "research and investigations within the broader BIF iron ore industry indicates the potential for successful propagation, establishment and survival of BIF specialist flora on appropriate translocation sites", although "successful establishment of post-mining rehabilitation that incorporates conservation-significant flora taxa or communities has not been demonstrated to date". With regard to the latter, MRL would add that most iron ore projects on BIF are not mature and therefore an opportunity to demonstrate successful establishment has yet to arise.

5.4.2 Proposed environmental management

The greatest potential impact on flora and vegetation is a direct reduction in extent through land clearing.

Options for avoidance of impacts due to land clearing have been considered and applied. Since referral to the EPA for assessment, the proposed disturbance area has been reduced by refining the Proposal to minimise the land clearing requirement.

The greatest potential impact is associated with the Bungalbin East open pit. There are also impacts associated with the J5 open pit. The location of these pits cannot be changed as they host the resource which is central to the Proposal. However, in this assessment MRL has used a disturbance area which, for the purposes of assessing the potential impact, has assumed all plants will be lost. In practice, it will be possible to avoid some conservation-significant vegetation and taxa occurring within the buffer area. This will require careful planning at the detailed design phase and will utilise existing MRL procedures relating to Site Disturbance Permits (MRL-EN-PRO-0005) and Land Clearing (MRL-EN-PRO-0004) to prevent unplanned clearing and to set the standards for clearing that is undertaken.

Given the limited capacity to further reduce direct impacts (see **Section 2.6**), consideration has been given to management of indirect impacts. MRL is confident these impacts can be managed using existing MRL procedures (**Table 5-26**) complemented by monitoring and some further site-specific procedures.

As mine operations will abut high value flora and vegetation, a monitoring program will be required to identify and respond to any adverse impacts that may arise as a result of mine operations. The program will monitor vegetation condition and plant health. It will be capable of distinguishing between localised impacts potentially attributable to mining operations and changes in condition due to general environmental conditions, such as those that might occur during an extended period of low rainfall. The monitoring program, including trigger and threshold criteria, is outlined in a draft Conservation-Significant Species and Communities Management Plan (CSSCMP) (**Appendix 5-H**).

TABLE 5-26: MRL PLANS AND PROCEDURES FOR FLORA AND VEGETATION

Doc. No.	Title	Description
MRL-EN-PLN-0001	Environmental Management Plan	Outlines the systematic approach to environmental management and outlines the standard expected for management of key environmental management activities, such as land clearing and weed hygiene.
MRL-EN-PRO-0004	Land Clearing Procedure	Describes procedures to be used when clearing land after a Site Disturbance Permit has been approved. Outlines identification, recovery and storage approaches for topsoils and subsoils.
MRL-EN-PRO-0005	Site Disturbance Permit Procedure	Describes the system of checks to be undertaken prior to any ground disturbance. Requires all proposed land clearing to documented, checked and approved by the site manager. Approval of clearing is conditional (must be conducted in a specified manner) and a system of checking and auditing is included ti verify compliance with each approved permit has been achieved.
MRL-EN-PRO-0007	Weed Hygiene and Control	Describes the approach to the preventing the introduction or spread of weeds. Concentrates on two areas – prevention of introduction or spread of weeds through transport of weeds into or across the site on earthmoving equipment or other vehicles, and on weed monitoring and control.
MRL-EN-PRO-0009	Land Rehabilitation	Describes the main considerations when rehabilitating land after mining and related disturbance. Discusses the planning, implementation and monitoring of rehabilitation works. A detailed rehabilitation management plan and a series of specific work instructions will be required for this Proposal.
MRL-EN-PRO-0012	Dust Management	Describes the general requirement to suppress dust generation from mining and processing activities. Includes outlines of the training and induction requires, routine dust control methods and monitoring. Site-specific work instructions will be required for this Proposal.
MRL-OHM-PRO-0007	Incident Reporting	Outlines MRL's requirements in regard to incident classification and required timeframes for the reporting of incidents by impact type and actual and potential consequence level.

Rehabilitation of disturbed areas is a critical issue. Done well, rehabilitation has the potential to restore some habitat and to replace numbers and genetic material of some conservation-significant taxa removed during land clearing, particularly in the case of the southern pit at Bungalbin East which will be partially backfilled. MRL considers that this area could support vegetation and taxa of conservation significance and will aim to create conditions under which this can occur where possible. Specifically, MRL would aim to reinstate particular genetic identities occurring within the Proposal disturbance area for two taxa, Tetratheca aphylla subsp. aphylla and Lepidosperma bungalbin. The approach taken to rehabilitation of disturbed areas is described in **Section 12**and in the draft Rehabilitation and Mine Closure Plan (**Appendix 12-D**) but would involve seed collection well in advance of land clearing, for the purposes of seedling establishment and use in direct seeding.

In respect of weeds and their management, routine weed hygiene controls will apply, as outlined in MRL-EN-PRO-0007. These measures include inspection of vehicles, earthmoving equipment and construction materials entering the site. Any items not meeting the requirements (free of mud or soil, vegetative debris, seeds, fauna) will be quarantined for cleaning prior to use. The site will also be equipped to undertake weed control in the event that weeds are observed during site inspections or monitoring. While the general approach is outlined in MRL-EN-PRO-0007, MRL will draft work instructions to address weed control works in close proximity to high value flora and vegetation.

Routine controls will also apply to dust management, as outlined in MRL-EN-PRO-0012. In addition to these controls, blasting controls and a monitoring program will be adopted. While modelling shows blasting to be a minor contributor to the overall dust load (see **Section 10.3.4**), MRL will adopt a work instruction detailing blasting controls to limit the potential for flora and vegetation within the PEC to be affected. These controls will consider wind direction and speed when preparing to undertake a blast. Wind roses for Southern Cross (**Figure 5-26**) indicate that, during winter, wind direction is primarily from the west which is favourable for taking dust away from the HAR. During summer, however, easterly winds commonly occur and blasting will need to be managed accordingly.

If unfavourable conditions exist, blasts can be delayed until wind speeds drop or wind direction changes. Similarly, blasts can be brought forward when conditions are favourable. A similar system successfully operated at Cliffs' Windarling operations.

It is also proposed to establish a dust monitoring program as outlined in **Section 10**. The program will involve dust deposition monitoring in and around vegetation near the Bungalbin East and J5 open pits together with a program of flora and vegetation health monitoring. One or more background dust deposition monitors will also be used to provide a basis for comparison. This monitoring program is discussed in more detail in the CSSCMP (**Appendix 5-H**) but is summarised in **Table 5-27**.

The CSSCMP also identifies trigger and threshold criteria that will be used in detecting and responding to possible indirect impacts on flora and vegetation. These trigger and threshold criteria are listed in **Table 5-28**.

To ensure the existing infrequent fire regime is maintained, MRL will not conduct any burning of vegetation. Other than a complete ban on fires, MRL will also have procedures for activities that carry some risk of inadvertent fire, such as welding or grinding (e.g. MRL-OHM-PER-0011 Hot Work Permit).

Fly and rill rock is usually caused by imprecision in how the blast is designed and conducted. Fly rock is readily prevented by close attention to the drill and blast design and initiation using quality control procedures.

The Proposal does not involve creation of any permanent water sources. In the absence of permanent water, the risk of a goat population establishing locally is very low. While rabbits occur locally, the Proposal is not expected to influence the local population, either positively or negatively, so there should be no increase in impact of vegetation grazing. Controls such as warren ripping could be implemented if necessary.

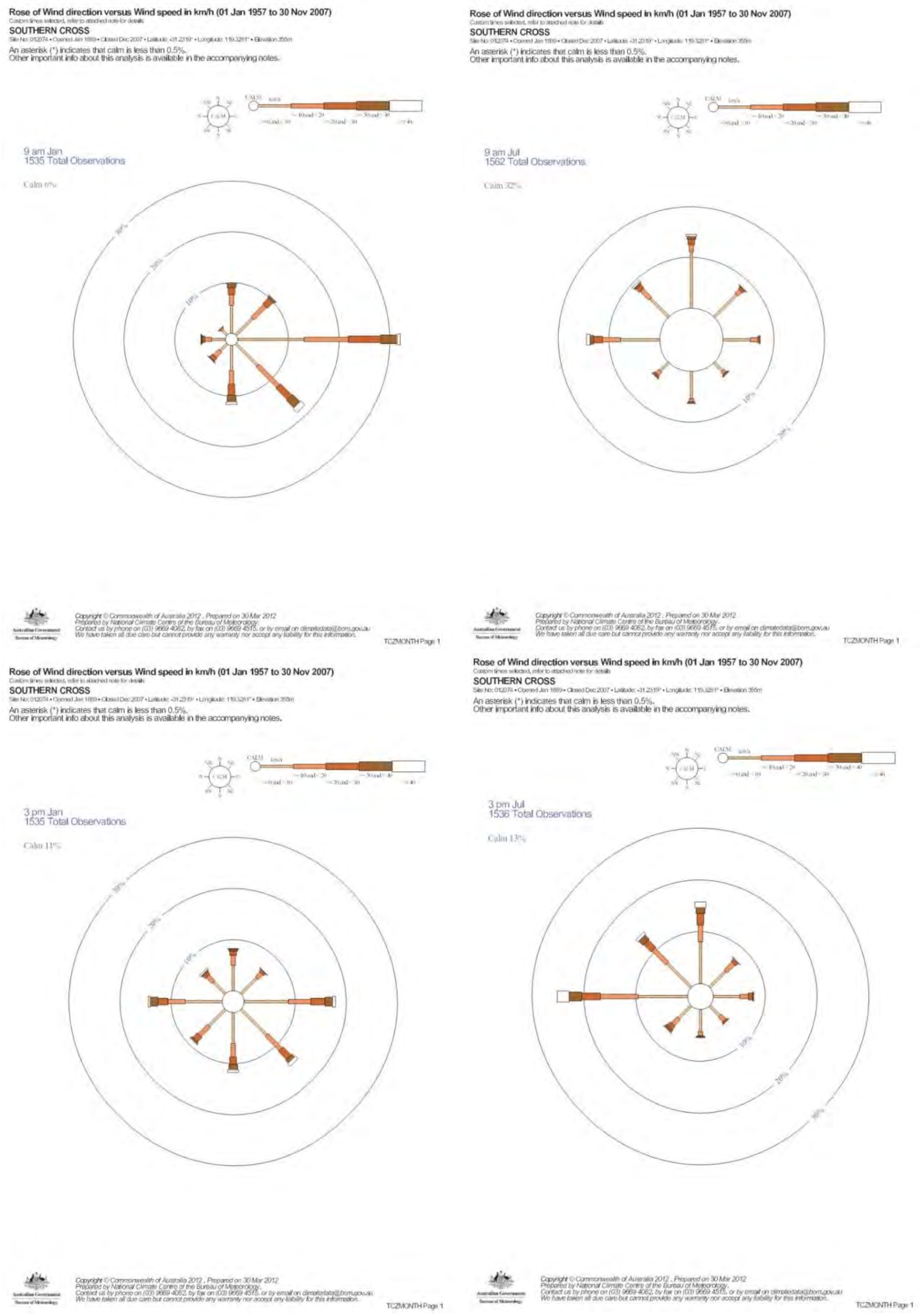

FIGURE 5-26: WIND ROSES FOR SOUTHERN CROSS (JAN AND JULY)

TABLE 5-27: PROPOSED MONITORING SCHEDULE

Item	Details and frequency
Conservation significant vegetation – remote sensing	Monitoring will be conducted immediately prior to Proposal commencement and every six months for the first two years of operations. After this period and in the absence of any documented impacts on vegetation from operations, an annual assessment will be conducted to provide a regular assessment of vegetation condition. This form of monitoring requires ground-truthing of initial monitoring parameters but can be conducted independently of ground studies once relationships are understood unless impact investigation is required.
Conservation significant vegetation – transects	Monitoring will commence prior to the commencement of construction and will be undertaken quarterly for the first two years of operations. A minimum of 30 plants of *Tetratheca aphylla* subsp. *aphylla*, *Lepidosperma bungalbin* and *Acacia adinophylla* will be monitored. A minimum of 10 individuals of *Leucopogon spectabilis* will be monitored. If no significant impacts have been recorded during the first two years of operations, the monitoring frequency will revert to annual.
Conservation significant flora	Monitoring will commence prior to the commencement of construction. Monthly program is envisaged initially with this reducing to quarterly after 12 months if impacts or significant issues such as heavy dust deposition are not recorded. If no impacts are recorded two years following commencement of mining operations the monitoring frequency will be reduced to annual.
Environmental variables	Meteorological conditions (daily commencing three months before commencement of construction).
	Dust deposition (minimum of five locations, to be monitored monthly commencing three months before commencement of construction).

TABLE 5-28: CONSERVATION SIGNIFICANT SPECIES AND COMMUNITIES –CRITERIA

No.	Trigger Criterion (measurable, proposal specific)	Threshold Criterion (measurable, proposal specific)
1	For Conservation Significant Vegetation (J5 and Bungalbin East): • An observable reduction in density of foliage chlorophyll associated with the mining operation and/or a recorded decline in vegetation health ranking score, relative to a control site.	For Conservation Significant Vegetation (J5 and Bungalbin East): • An increased reduction in density of foliage chlorophyll or an increase in the extent of the originally reported decline associated with the mining operation and/or a recorded decline in vegetation health ranking score of more than 2 levels relative to a control site.
2	For any species of conservation significant flora (Bungalbin East): • A change in health score of -1 (on a scale of 0-5) of plants in impact susceptible sites with no corresponding reduction in health score recorded for plants at control sites.	For each species of conservation significant flora: • A change in health score of -1.5 (on a scale of 0-5) of plants in impact- susceptible sites with no corresponding reduction in health score recorded for plants at control sites.

5.5 Residual impacts

MRL has identified the following residual impacts:

- Removal of up to 385.4 ha (6.9 %) of the HAR PEC. This amount assumes full loss of vegetation within the 20 m buffer surrounding the mine pits, waste rock dumps and supporting infrastructure areas. Given there is little other existing disturbance, over 90 % of the PEC would remain if this Proposal was implemented. MRL notes that when impact is based on the PEC analogue determined by ecologia Environment, the proposed impact reduces to 267.3 ha (5.3 %) on the same basis (assuming loss of vegetation within the buffer). This is well below the retention threshold of 30 % identified by (Environmental Protection Authority, 2000) to prevent biodiversity loss, although given the conservation significance of the vegetation, a much higher level of protection would be warranted. While the diversity, viability and function of the PEC will remain, the residual impact is significant.
- Removal of individual vegetation units contained within the PSRN supergroup and which host taxa of conservation significance. Particular vegetation units affected are PSRN6, PSRN7 and PSRN23. Vegetation unit PSRN7, a *Eucalypt* woodland occurring on the slopes below the ridgeline, has a current extent of 47 ha of which over 36 % would be removed under the Proposal. The residual impact is significant.
- Removal of almost 26,000 individuals (29.4 %) of the threatened *Tetratheca aphylla* subsp. *aphylla* (including those plants in the buffer). This taxon is not known outside of the HAR. Some plants within the disturbance area of the Bungalbin East pit exhibit some degree of genetic differentiation from plants outside of this area. Targeted offsets and rehabilitation are proposed to reduce the residual impact which may still be considered significant.
- Removal of over 18,000 individuals (39.7 %) of the P1 *Lepidosperma bungalbin* (including those plants in the buffer). This taxon is not known outside of the HAR but is locally abundant on steep BIF slopes. Genetic studies identified there would be negligible impact on genetic variation and spatial genetic structuring, although one distinct genetic cluster would be significantly reduced without successful rehabilitation. While the taxon will remain well represented, the residual impacts are considered significant.
- Removal of over 1,000 individuals (12.3 %) of the P1 *Acacia adinophylla*. This taxon is not known outside of the HAR but is locally common and further surveys are likely to increase the number of known plants. Genetic studies identified there would be negligible impact on genetic variation and spatial genetic structuring. The residual impacts on A. *adinophylla* are not significant.
- Removal of small numbers of individuals (~1 % or less) of the threatened *Leucopogon spectabilis* and the P1 *Acacia shapellae*. While neither taxon is known outside of the HAR, the residual impacts are not significant.
- Removal of a number of individuals of P3 and P4 taxa, the most substantial impact of which is on *Banksia arborea* (P4). The Proposal will require removal of 18.8 % of plants of the known population of B. *arborea*. However, the taxon occurs widely across the region and the residual impacts are not significant.

While the removal of individuals of the two threatened taxa is not expected to warrant reconsideration of their IUCN threat ratings, L. *bungalbin*, currently listed as a Priority 1 flora taxon, could come under consideration to be Vulnerable under IUCN criteria. This may be the case whether the Proposal proceeds or not as there is now sufficient survey information on which to make a determination (**Appendix 5-A**).

MRL considers that the indirect impacts associated with this Proposal are manageable using existing environmental procedures, as summarised in **Table 5-26**, together with the application of other Proposal-specific management directives (CSSCMP, work instructions) that will be required.

To counter the significant residual impacts, MRL proposes an offset package to assist with the management of conservation values within the HAR and elsewhere. The offset package is described in **Section 13**.

In addition to the offset package, MRL will seek to re-establish suitable habitat for significant taxa where possible through rehabilitation work, in particular within the partially backfilled southern pit at Bungalbin East (see **Section 12**).

5.6 Predicted Outcome

The EPA’s objective for flora and vegetation is “to maintain representation, diversity, viability and ecological function at the species, population and community level”.

Land clearing associated with this Proposal will have a localised but significant impact on elements of the flora and vegetation at the HAR. In considering the EPA’s objective for flora and vegetation, representation and diversity will be unaltered as there are no taxa, vegetation units or supergroups that will be removed.

Following investigations into intra-species diversity, some measures are proposed to prevent the loss of some genetic differentiation in *Tetratheca aphylla* subsp. *aphylla* and *Lepidosperma bungalbin*. Viability of key elements of flora and vegetation is a primary consideration given that many are restricted in their range and occurrence. While the Proposal involves removal of individuals of threatened and Priority taxa, and of a small proportion of a PEC, it also offers the opportunity to gain a better understanding of their ecology through research and monitoring.

Although the Proposal will permanently remove a portion of habitat, the viability of taxa and vegetation within adjacent areas can be maintained through careful implementation of the Proposal and application of management measures to protect or enhance remaining populations. Ecological function can be maintained within intact vegetation which will remain unaltered.

Through an offsets program (**Section 13**), the Proposal offers an opportunity to achieve on-ground improvements elsewhere within the MMHARCP.

It is concluded that the EPA’s objective for flora and vegetation can be met.

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6. LANDFORMS

6.1 EPA objective and policies

The EPA objective for landforms is:

- To maintain the variety, integrity, ecological functions and environmental values of landforms.

The policy and guidance documents referenced as part of the field investigations and impact assessment are provided in **Table 6-1**.

TABLE 6-1: LEGISLATION, POLICIES AND GUIDANCE CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key Aspects of Policy	How Applied
EPA Policy and Guidelines		
EPA (2015a). Environmental Protection Bulletin No. 23: Guidance on the EPA Landforms Factor. Perth, Western Australia.	This EPB provides high level guidance for consideration by proponents on the EPA's objective for the Landforms factor. The focus of the EIA process will be on the significance of the landform itself and the significance of the impacts on the landform. The extent and environmental consequence of these types of impacts will be considered, along with how these impacts may be avoided or minimised in order to meet the EPA's objective for the Landforms factor. In considering these impacts, the EPA will focus on the significance of the removal or alteration of the landform's defining features (geology and morphology) in a local or regional and cumulative context.	The assessment of potential impacts on landforms is detailed in **Section 6.3**. MRL undertook a detailed Landform Impact Assessment (**Appendix 6-A**) that utilised desktop analysis and a site assessment using key landform elements e.g. elevation and slope. A peer review (**Appendix 6-B**) of the work was undertaken which considered the impact assessment against other available information including EPB 23.
EPA (2006) Guidance for the Assessment of Environmental Factors No. 6: Rehabilitation of Terrestrial Ecosystems. Perth, Western Australia	Focuses on effective use of completion criteria to measure biodiversity in rehabilitation projects. Aims specifically at increasing the quality, uniformity, and efficiency of standards and processes for rehabilitation of native vegetation in Western Australia and to allow more effective monitoring and auditing of outcomes.	A Rehabilitation and Mine Closure Plan (RMCP) (**Appendix 12-D**) was prepared in accordance with this guideline and outlines completion criteria for the Proposal.

Legislation, Policy and Guidelines	Key Aspects of Policy	How Applied
EPA (2007) Report 1256: Advice on areas of the highest conservation value in the proposed extensions to Mount Manning Nature Reserve. Advice of the EPA to the Minister for Environment under Section 16(e) of the *Environmental Protection Act 1986*.	The advice primarily concerns Mt Manning Range Nature Reserve and proposed extensions, also known as the Yilgarn Conservation Reserves. This advice identifies areas that should be protected from mining and the use of environmental offsets. The advice makes numerous reserve recommendations including that part of the MMHARCP be reserved as an A Class Nature Reserve for protections of, amongst other things, exceptional landforms. The key factors listed in the advice include "substantial landforms with significant visual amenity."	The PER considers the impact of the Proposal on landforms (this section) and visual amenity (**Section 10**).
EPA (2008) EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development. Perth, Western Australia	Provides information and advice on a range of environmental issues and their protection and management, including landscapes and landforms. It identifies landforms of high significance that must be given a high level of protection, including the public conservation reserve system (e.g. conservation parks). The EPA is unlikely to recommend the approval of projects that have significant adverse impacts on landscapes and landforms of high conservation significance except in special circumstances. Where special circumstances for development exist, the EPA recommends that the procedures for mitigating adverse impacts are followed as set out in Position Statement No. 9 (EPA 2006).	EPB 23 has been the main guidance adopted for EIA of landforms. GS33 makes reference to situations where offsets may be appropriate and refers to Position Statement No. 9 Environmental Offsets. PS9 has been superseded by the WA Environmental Offsets Policy 2011, the WA Environmental Offset Guidelines 2014 and EPB No. 1 Environmental Offsets. Refer to **Section 13** with regard to the applicability of offsets for the Proposal and the environmental offsets being proposed by MRL.
DMP and EPA (2015) Guidelines for Preparing Mine Closure Plans.	Outlines the DMP's and EPA's requirements for planning mine closure, decommissioning and rehabilitation in order to meet the DMP and EPA's objectives.	A RMCP (**Appendix 12-D**) has been prepared in accordance with this guideline.

This PER has been prepared to be consistent with all policy and guidance documents referenced in **Table 6-1**.

6.2 Existing environment

6.2.1 Study area definition

The extent of the HAR is defined in the ESD (see **Figure 6-1**) as six distinct landforms occurring within a Local Assessment Unit (LAU). These landforms were identified by the OEPA based on geology and morphology, and comprises the area having a slope of five degrees or greater together with an additional 50 m buffer to allow for lower resolution source data. For ease of reference, the landforms of the LAU (i.e. the HAR) are designated as L1-L6.

The LAU is provided in the ESD for the purpose of characterising the significance of the landforms in a local context. The landforms of the LAU that will be disturbed as a result of the Proposal are referred to in the ESD as the Potentially Affected Landforms (PALs). The boundary of the LAU in relation to the HAR and the MMHARCP (in which the HAR is located) is shown on **Figure 6-1**.

To provide regional context, the ESD defines a regional study area boundary (see **Figure 6-1**). This regional study area is confined to the Mount Manning area and includes indicative BIF derived from data from the Geological Survey of Western Australia (GSWA) and land systems spatial data from the Department of Agriculture and Food Western Australia (DAFWA).

6.2.2 Desktop analysis and survey

A Landform Impact Assessment (LIA) was conducted by Bioscope Environmental in 2015-16 (**Appendix 6-A**) to describe the landforms of the LAU within the context of the wider region.

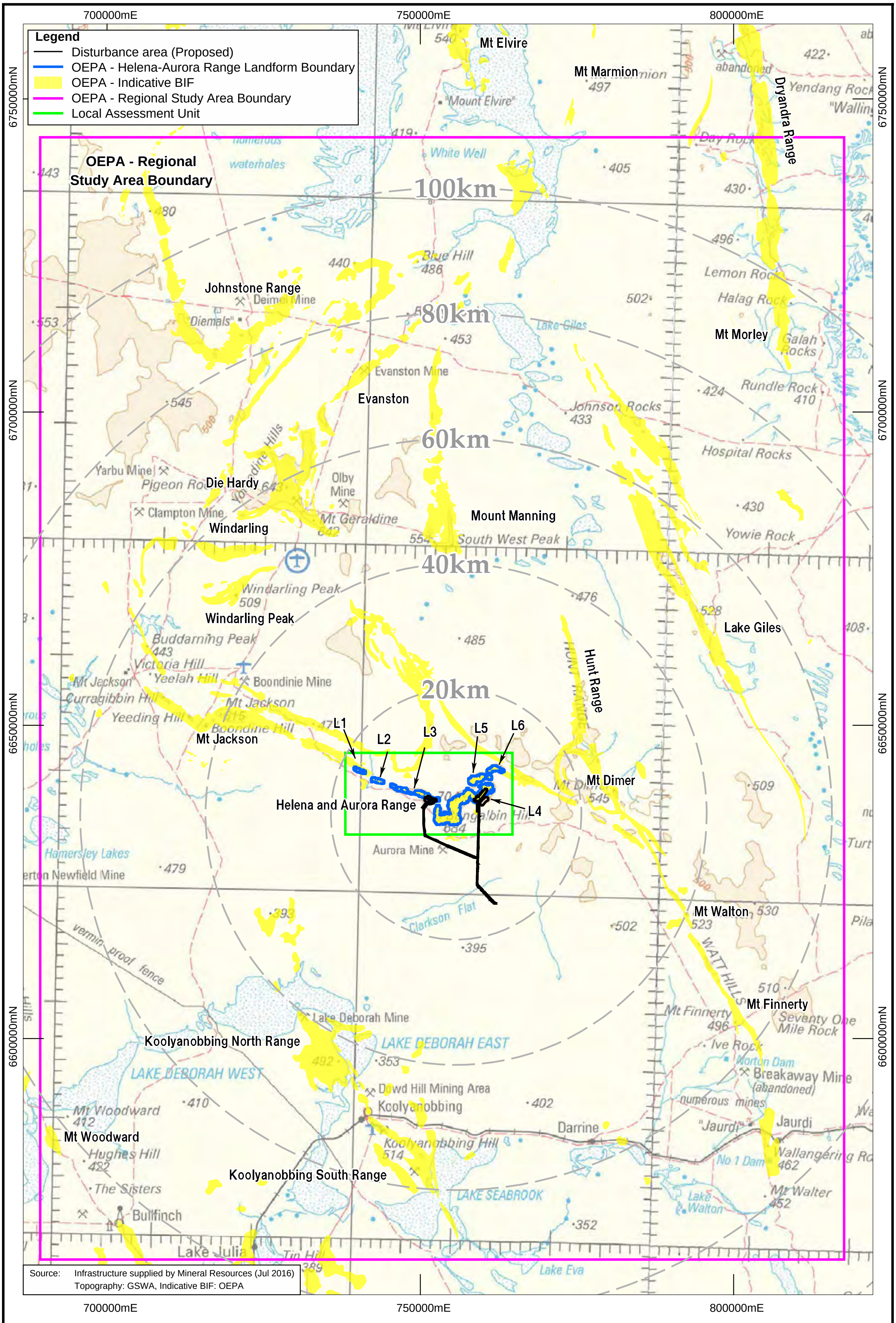
The ESD requires that the significance of the potentially affected landforms be characterised in a local and regional context, having regard to variety, integrity, ecological importance, scientific importance and rarity.

Following review of the ESD and the questions posed in this document in relation to the aspects above, it is apparent that variety and rarity are defined by similar elements (such as similarity, representation and importance) and that “importance” in this context relates to the site’s ecological and scientific status or significance.

The landforms have therefore been characterised in a local and regional context in relation to the key elements of variety and integrity, with rarity, scientific importance and ecological importance being considered as part of variety.

The relationship between these aspects is outlined in **Figure 6-2**. Information on the variety of landforms (rarity, scientific importance and ecological importance) is provided in **Section 6.2.9**. Information on the integrity of the landforms is provided in **Section 6.2.10**.

To reduce subjectivity in the LIA, the landforms of the LAU were described using six landform analysis criteria (elevation, slope, aspect, Topographic Position Index [TPI], Wetness Index and solar radiation). Data in relation to these criteria are provided in **Appendix 6-A** and discussed where relevant in **Section 6.2.5**. These data were supplemented by data collected in the field from 26 sites (see **Appendix 6-A**) and are also discussed in this chapter, where relevant.



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LANDFORM ASSESSMENT BOUNDARIES

Figure:

6-1

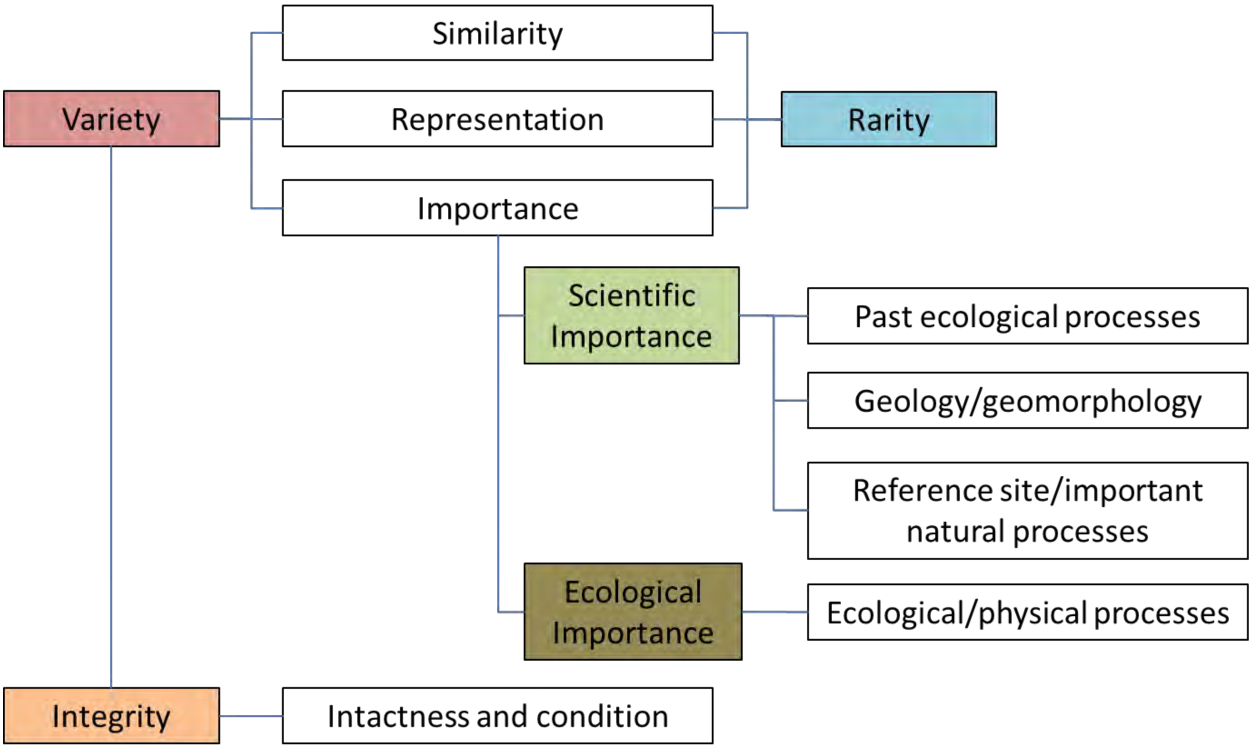


FIGURE 6-2: LANDFORMS – VARIETY, INTEGRITY AND RARITY

Peer review

MRL commissioned a peer review to provide assurance that the LIA undertaken by Bioscope Environmental has addressed the requirements outlined in the ESD and EPB No. 23. A copy of the peer review close-out report is provided in **Appendix 6-B**.

The peer review was conducted by Dr Karl-Heinz Wyrwoll of the University of Western Australia, who concluded that the report provides:

- recognition of landform attributes and wider geological-geomorphological context of the HAR
- recognition that the HAR is one of a suite of BIF ranges present throughout the Yilgarn Craton
- identification of the components of the geomorphological-landform setting and their significance
- recognition of landform attributes that carry ecological implications specific to the HAR
- consideration of the likely importance of past ecological processes
- an outline of measures to be adopted in landform remediation, but only at a very general conceptual level and lacking in technical detail (noting that further detail on landform remediation/rehabilitation is provided in the PER document and that review of this information was beyond the Terms of Reference for the review).

The peer review made a number of suggestions for further work which focussed mainly on developing a better understanding of the geomorphology of the landform and the impact of the Proposal in terms of geomorphological processes.

The review noted that the ridge margin colluvial slopes and associated valley/sandplain geomorphological terrains are more sensitive to likely disturbances associated with the Proposal. The likelihood of erosion of these associations is potentially captured through the calculation of the Wetness Index, but the review suggests that the erosional implications that this carries needed to be outlined more fully. When linked to the surficial geology, the erosion potential (sensitivity) of the colluvial slopes and associated valley setting can be attained.

In response, additional information on geomorphological processes was subsequently included in the report (**Appendix 6-A**), helping to highlight the functional relationship between the geomorphological components and bring awareness to the geomorphological sensitivity of the landform.

The peer review also suggested that Table 3-2 of the report (**Appendix 6-A**) revised with a focus on relationship between geology (bedrock and surficial) and geomorphological expression. MRL notes that while this may be a useful exercise from a scientific perspective, there is little to be gained in terms of understanding whether or not the Proposal will have a significant impact on the landform in the context of the EPA's objective for the landforms factor.

The way in which geology and lithology influence geomorphological expression in the landforms is discussed in **Section 3.3.1** and illustrated for the J5 and Bungalbin East pit areas in **Figure 3-4** and **Figure 3-5**.

The peer review also noted that the LIA report lacks an awareness of future climatic events and that such projected changes may well be necessary considerations in predicting landform response, in addition to playing an important role in remedial landform design.

In response, the LIA report was amended to include reference to cumulative impact on landform over future climate events, based on climate change predictions for the region (Loechel, et al., 2010). MRL has adopted conservative design criteria in its closure planning for the Proposal, so further allowance for climate change is not required at this time.

The peer review close-out report (**Appendix 6-B**) concluded that a sufficient outline of the landform and its geomorphological function is provided to allow conclusions to be drawn that allow the assessment criteria to be evaluated. MRL therefore considers the LIA meets the intent of EPB23 and is appropriate for assessment of potential landform impacts of this Proposal.

6.2.3 Regional context

Greenstone belts of mafic volcanics and BIF are common in the northern and eastern parts of the Yilgarn Craton (Markey & Dillon, 2011a) with BIF-dominated landforms being well represented in the local and regional area. **Table 6-2** and **Figure 6-3** provide the location of elevated landforms within the Mount Manning area, many of which include BIF components. The area identified for the purpose of regional context has been defined by the EPA, as per Figure 5 of the ESD for the Proposal.

Although BIF-dominated landforms are common throughout the Mount Manning area, data provided in **Table 6-2** indicate that the heights, maximum slopes and majority aspects of landforms in this region are quite variable. Based on available data, the HAR has a similar range of elevations compared to the Mount Manning, Mount Jackson and Die Hardy ranges (**Figure 6-3**).

There are other similarities within the regional landforms. Based on available data (**Table 6-2**), the HAR has similar maximum slopes to the Mount Jackson Range, Die Hardy, Mount Manning Range, Koolyanobbing Range and Highclere Hills (**Figure 6-3**). Further, the HAR has a majority aspect similar to the Mount Jackson Range, Evanston and Highclere Hills (**Table 6-2**).

In terms of landform integrity, the HAR has similar levels of intactness (>99%) as the Die Hardy Range, Dryandra Range, Hunt Range, Johnston Range, Lake Giles Range and Mt Manning Range (**Table 6-2**).

TABLE 6-2: REGIONAL LANDFORMS – COMPARATIVE ANALYSIS

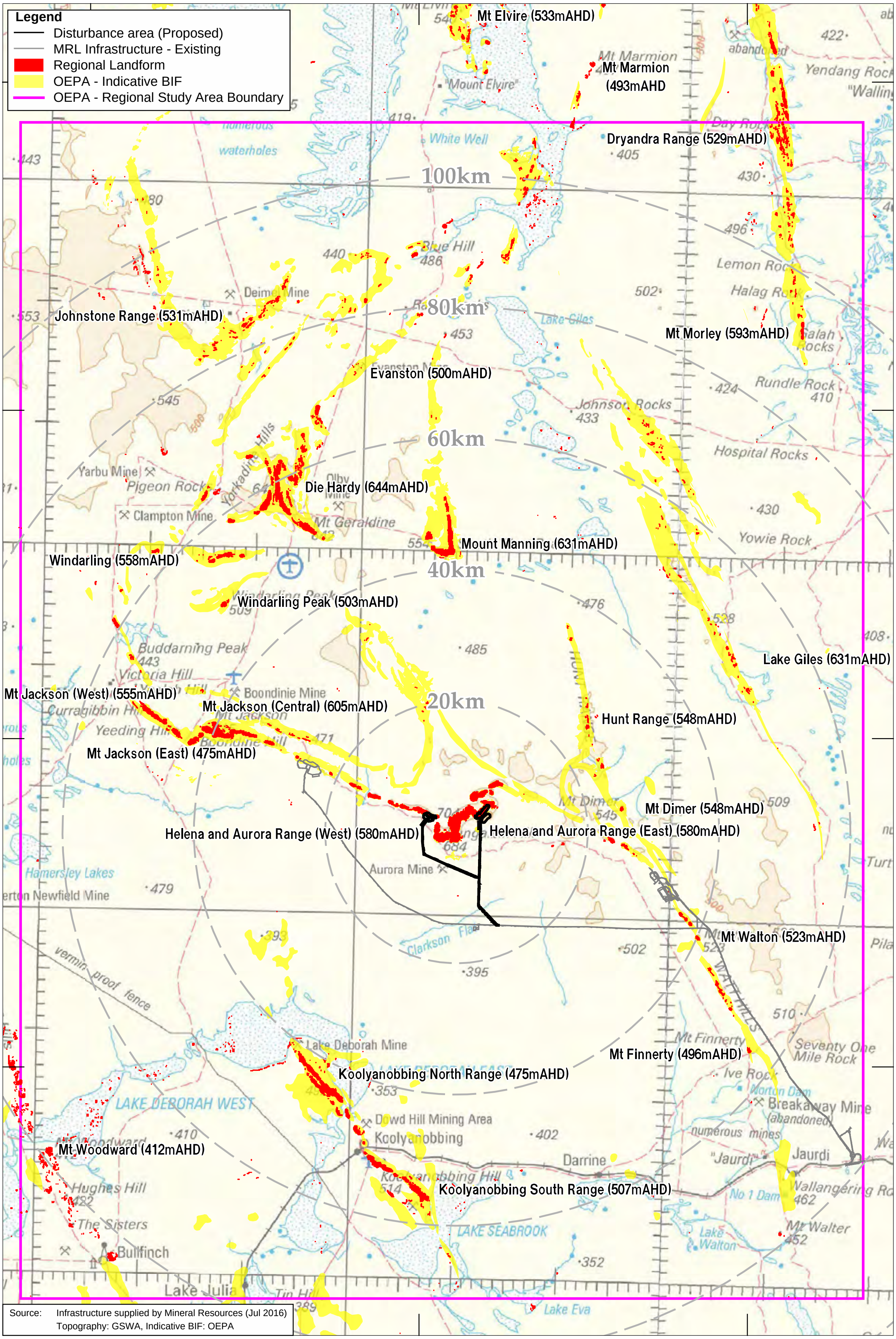
Landforms	Area (ha)[1]	Height (mAHD)[2]	Maximum Slope[2]	Majority Aspect[3]	Integrity[4]			
					Disturbance		Intactness	
					Area (ha)	%	Area (ha)	%
Die Hardy	2,625.6	460 - 644	22°	75°	16.7	0.6	2,608.9	99.4
Dryandra Range	1,098.2	414 - 529	13°	78°	1.9	0.18	1,096.2	99.8
Evanston	13.5	468 - 500	5°	149°	2.9	21.8	10.6	78.2
Finnerty Range/Mt Dimer/Y. Hills	412.0	446 - 548	13°	244°	12.7	3.1	399.3	96.9
Helena-Aurora Range	2,913.3	447 - 692	26°	180°	11.0	0.4	2,902.2	99.6
Highclere Hills	1,128.8	235 - 492	31°	225°	118.7	10.5	1,010.1	89.5
Hunt Range	151.9	449 - 548	9°	86°	0.31	0.2	151.6	99.8
Johnston Range	751.8	444 - 531	11°	289°	1.9	0.2	749.9	99.6
Koolyanobbing Range	2,148.4	321 - 507	24°	45°	291.8	13.6	1,856.5	86.4
Lake Giles Range	384.6	437 - 525	8°	105°	2.6	0.7	382.0	99.3
Mount Jackson Range	1,669.7	425 - 605	22°	195°	148.6	8.9	1,521.1	91.1
Mount Manning Range	803.2	434 - 631	25°	270°	0.9	0.1	802.3	99.9
Windarling Peak	71.6	427 - 503	12°	97°	4.0	5.6	67.6	94.4
Windarling Range	254.1	440 - 558	16°	341°	110.2	43.4	143.9	56.6

[1] Total area of HAR landforms differs from the LAU analysis due to minor variation in the criteria used to identify regional landforms.

[2] Height classes and majority slope differ from the LAU analysis as different scales of data were used for the regional analysis of landforms.

[3] 0° refers to north-facing; 90° refers to east-facing; 180° refers to south-facing; 270° refers to west-facing.

[4] Areas of existing disturbance for the HAR differs from the LAU analysis due to minor variation in the criteria used to identify regional landforms.



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REGIONAL LANDFORMS

Figure: **6-3**

6.2.4 Landforms of the LAU

The HAR rises up approximately 200 m above an otherwise relatively flat landscape to reach 702 mAHD at its highest point. Bungalbin Central comprises the largest continual area of the ranges (L4) and includes Bungalbin Hill (**Figure 6-1**). Two smaller areas of the HAR (L5 and L6) occur to the northeast of the central area (**Figure 6-1**).

These three areas of the HAR have a generally higher elevation than the western portion (L1-L3) which is characterised by more gently rounded hills that are visually similar to the eastern extent of the Jackson Range.

It is noted that the HAR and Koolyanobbing Range are the most visually prominent features in the area mapped by Newbey (1985) (**Figure 6-4**), with the HAR being the most visually prominent feature in the LAU.

Newbey (1985) maps the HAR as “Hill (Banded Iron Formation)” (**Figure 6-4**). This category of landform is described as hills with stony slopes that rise above the surrounding plains. The eroding upper slopes are inclined at 10-20°, while the lower colluvial slopes are 5-10°. Soils on the upper slopes are mainly skeletal and become shallow on the lower slopes. These hills commonly have bedrock exposures on steep slopes and crests (Newbey, 1985).

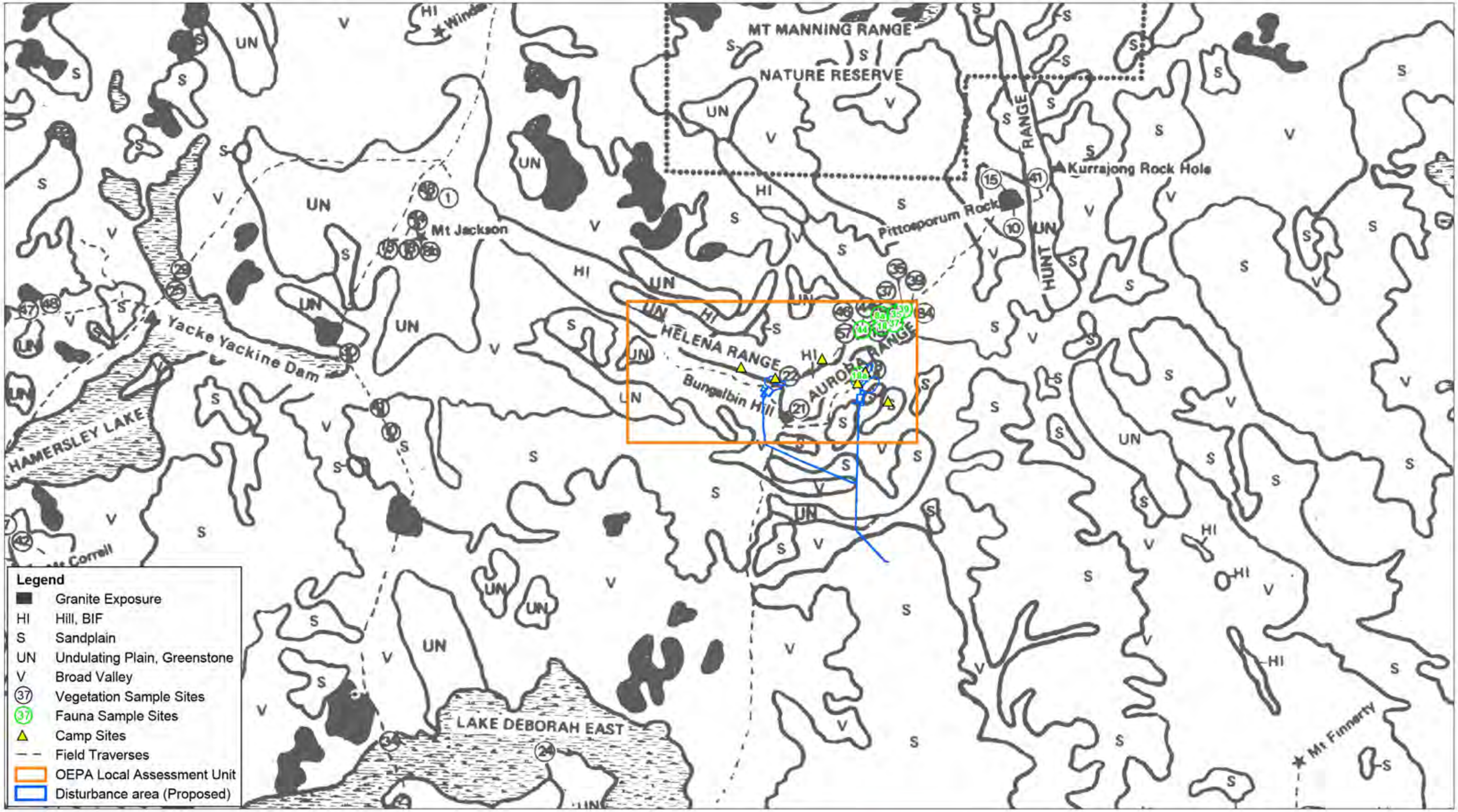
Along ridge lines within the HAR, erosion of the friable weathered surface gravels has resulted in a relatively thin layer of gravel (0-10 cm deep) over the solid ironstone. This unit is defined by Soilwater Consultants as SMU 1: Skeletal Gravels (**Appendix 12-A**). With increasing distance downslope, the thickness of the surface gravels gradually increases due to colluvial deposition, resulting in the formation of SMU2: Shallow – Deep Gravels. With the majority of the coarser textured particles (i.e. gravels) deposited in upslope areas, the soils become predominately fine-textured as distance downslope increases. These finer-textured soils have been defined by Soilwater Consultants (**Appendix 12-A**) as SMU 3: Deep Alluvial Clays and effectively form the plain soils surrounding the outcropping BIF ridges. These soils occur throughout the Yilgarn (**Appendix 12-A**).

Bedrock exposures are common on the steep slopes and crests, and scree slopes occur in a number of locations throughout the HAR. Chen and Wyche (Chen & Wyche, 2003) describe BIF scree as containing angular and poorly-sorted clasts in a siliceous matrix of BIF. Rocky outcrops are common within the central and eastern portions of the HAR (L4-L6) and caves and small cliff faces are also present in some areas.

The plains surrounding the hills and ridges of the HAR comprise three separate landform units. The Broad Valley and Sandplain landforms dominate the flatter portions of the LAU, while Undulating Plains (Greenstone) occur within the LAU to the north and southwest of the HAR (Newbey, 1985).

The Broad Valley landform comprises the choked remnant of a former drainage system which was active under a higher rainfall regime than occurs now. The valley floors occur 20-50 m below the surrounding Sandplain and are flat to gentle-concave with slopes of less than 2°. Newbey (1985) notes that the soils of this landform have an intricate history of in situ weathering, colluvial, alluvial and aeolian actions, and that Valley carbonates have been largely leached from the surrounding Sandplain. Consequently, an important soil aspect is the calcareous B horizon (Newbey, 1985).

The Sandplain landform comprises the almost flat upland plain and the upper and middle valley slopes. Newbey (1985) defines the dividing line between Sandplain and Broad Valley as the change from erosional to colluvial valley slopes. Sandplain slopes rarely exceed 2° and the internal relief is rarely more than 15 m (Newbey, 1985).



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
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REGIONAL LANDFORM TYPES

Figure: 6-4

Newbey (1985) notes that Sandplain soils have developed over a long period of time and have been laterized to some extent. Extensive sand sheets with a major component of colluvium from slightly higher places on the Sandplain have developed in some places, and, occasionally, vegetated remnants of small dunes from drier periods are present. There are no definitive drainage lines, but flows may occur over short distances following heavy and intense falls of rain (Newbey, 1985).

The Undulating Plains comprise low rises and ridges interspersed with colluvial flats that range from 50 m to 500 m in width and are drained by channels up to 1 m deep and 5 m wide. Most rises and ridges are less than 5 m above the flats and have slopes that rarely exceed 10°. Soils on the colluvial flats rarely exceed 1 m in thickness, are shallow on the rises and skeletal amongst bedrock exposures on the ridges (Newbey, 1985).

6.2.5 Geology of the HAR

EPB 23 states that a landform can be defined through the combination of its geology (composition) and geomorphology (form). Geomorphology considers landforms and their formative processes, particularly the earth-surface processes of weathering, erosion, transport and deposition, and their rates of occurrence (Matthews & Herbert, 2008; Sturman & Spronken-Smith, 2001). In comparison, lithology is the specific study of rock characteristics, particularly grain size, particle size and physical and chemical character (Whittow, 2000).

The geology of the HAR and the geological processes that contributed to formation of the ranges are described in **Appendix 6-A** and summarised below. The lithology of the HAR and its influence on the ranges' geomorphology is described in **Section 6.2.6**. Information on specific characteristics of the HAR landforms is provided in **Section 6.2.7**.

The HAR is part of the 3 Ga Marda-Diemals Greenstone Belt which is divided into three lithostratigraphic groups (Chen & Wyche, 2003):

- Lower group dominated by tholeiitic basalt with minor ultramafic rocks
- Middle group composed almost entirely of BIF and chert
- Upper group comprising a variety of rocks types including basalt, BIF, chert and minor siltstone and shale

These rock types are unconformably overlain by the younger 2.73 Ga felsic to intermediate volcanic rocks and clastic sedimentary rocks of the Marda Complex. The Marda-Diemals Greenstone Belt contains some major and minor BIF units, which are the host precursors to the iron ore deposits in the region (Chen & Wyche, 2003).

"Banded Iron Formation" is a term applied to a very unique sedimentary rock of biochemical origin. BIFs were formed in sea water as the result of oxygen being released by photosynthetic bacteria. The oxygen combined with dissolved iron in the sea water to form insoluble iron oxides. The iron oxides precipitated out, forming a thin layer on the ocean floor. Each layer is assumed to be the result of cyclic variability of the oxygen content of the sea water. The BIFs of the HAR formed during the Archaean, approximately 3 Ga (Chen & Wyche, 2003).

The BIF consists of alternating layers of iron oxides (magnetite [Fe_3O_4] or hematite [Fe_2O_3]), chert, jasper and shale. The width of the alternating layers can be from millimetres to several metres, with the formation itself being tens to hundreds of metres in both width and thickness. The colour of the BIF is related to its bands with the iron oxide bands ranging from a steel grey-blue to red, the chert bands ranging from white through to black, grey, or yellow, and the jasper bands being a dark, blood-red colour.

Formation of the HAR was a complex process involving three deformational events to form the current land surface. The HAR underwent thrust faulting in the first deformational stage which caused a repetition of the HAR BIF units in the Bungalbin Syncline. By the close of the third deformational event, the HAR had been uplifted, refolded and slightly rotated to reach its current northwest dipping current position (Chen & Wyche, 2003).

The current surface of the HAR is a mixture of goethite and hematite-weathered BIF covered in part by a laterite derived from the underlying weathered BIF. The more siliceous parts of the BIF have not weathered and these account for the steep flanks of the range as well as the main ridge line. In areas of structural weakness, the BIF has been altered to massive goethite with some hematite. The main concentrations of these occur at the J5 and Bungalbin East iron ore deposits. See **Section 6.2.6**.

6.2.6 Lithology of the HAR

As indicated in **Section 6.2.5**, the current surface of the HAR is a mixture of weathered BIF partly covered by laterite derived from the underlying weathered BIF. The more siliceous parts of the BIF have not weathered and these account for the steep flanks of the range as well as the main ridge line. In areas of favourable structure, ore-forming fluids have altered the BIF to massive goethite mineralisation bodies with some hematite, with the main concentrations of these occur at J5 and Bungalbin East. Minor uneconomic mineralisation also occurs on the flanks of the range at Bungalbin Central.

All of the lithological units mapped within the J5 and Bungalbin East pit areas have been recorded within the wider HAR (**Table 6-3** and **Figure 6-5**). The most common lithological unit within the HAR is Siliceous BIF (at 38.4 %). This is also the most common unit within the mine pits at Bungalbin East (37.6 %) and the second most common unit within the mine pit at J5 (29.1%).

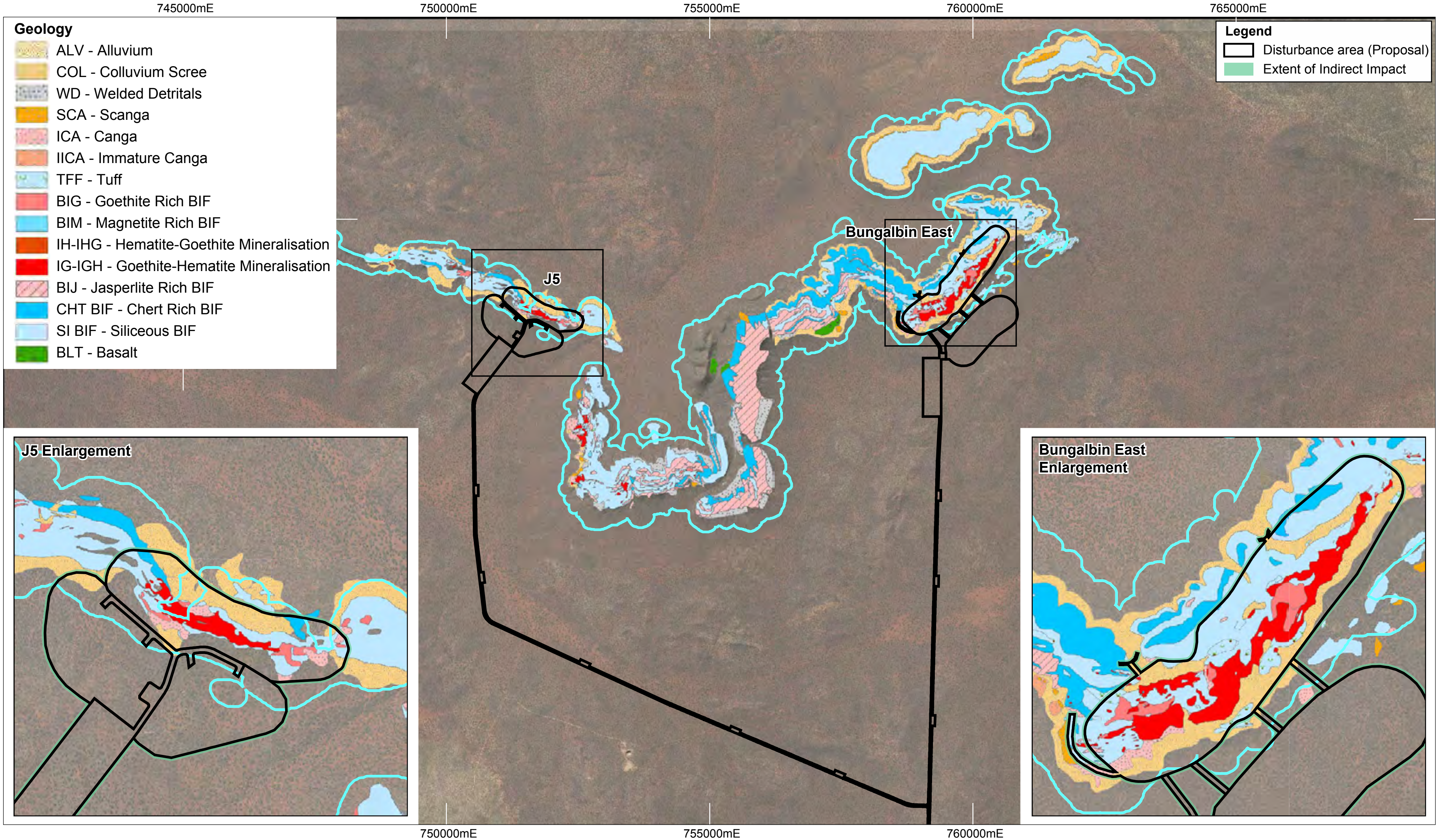
TABLE 6-3: LITHOLOGY OF THE POTENTIALLY AFFECTED LANDFORMS

Lithological Unit	Description	Area (%)		
		HAR	J5 Pit	B. East Pit
Banded Iron Formation (Siliceous BIF)	Millimetre to metre scale beds of alternating silica and ironstone (magnetite, hematite, and commonly goethite). Many variations of BIF are found across the range including abundant red jaspilite, pale cherts and enriched bodies of goethite and sometimes hematite.	38.4 %	29.1 %	37.6 %
Colluvium Scree	Loose, unconsolidated sediments that have been deposited at the base of hill slopes by rain-wash, sheet wash, slow continuous downslope creep, or a variable combination of these processes. The colluvium is typically composed of sub-angular to well-rounded pebble to cobble sized BIF, basalt, jasperlite, and chert.	21.1 %	32.0 %	23.9 %
Jasperlite rich BIF	An iron-rich, prominently red chalcedonic quartz which occurs in the BIF and banded chert horizons.	13.8 %	0.0 %	0.3 %
Goethite Mineralisation	Total replacement of BIF through chemical weathering occurring as bands/horizons within altered BIF, iron-rich basalt and canga. Goethite is the principal iron mineralisation type.	2.7 %	14.8 %	20.8 %

Lithological Unit	Description	Area (%)		
		HAR	J5 Pit	B. East Pit
Alluvium	Loose, unconsolidated silt, clay, sand and gravel. Alluvium is restricted to areas where clear drainage channels are present.	0.2 %	0.0 %	2.4 %
Welded Detritals	Late stage detrital material comprising clasts of host rock (BIF and chert dominant) in a re-cemented, siliceous, fine grain matrix. Typically found as a thin 'veneer' at the base of the non-mineralised BIF sections of the range.	5.5 %	0.0 %	0.0 %
Canga and Scanga	Pisolitic detrital units re-cemented in a hard, iron rich matrix, formed by the chemical and mechanical weathering of bedded iron deposits. Scanga is interpreted as a canga with high silica content either within the matrix or clasts. This unit is generally identified down slope (at the base) of bedded iron deposits.	3.0 %	8.4 %	2.8 %
Tuff	A soft, fine grain, sometimes porphyritic unit predominantly found in low lying saddles and occasionally on the flanks of the range.	1.7 %	0.0 %	4.7 %
Banded Iron Goethite	A goethite-rich BIF generally occurring on the margins of the main deposits. Silica still remains although iron is dominant. It has also been observed within highly mineralised rock.	1.1 %	5.4 %	5.2 %
Magnetite rich BIF	Magnetite widely distributed as bands in the BIF and as interstitial crystals in mafic and ultramafic rocks.	0.1 %	0.0 %	0.0 %
Hematite Mineralisation	Weathering product of magnetite occurring as beds/horizons within altered BIF, iron-rich basalt, and canga.	0.0 %	0.0 %	0.0 %
Chert	Fine grain, silica rich sedimentary unit often occurring in layered beds alternating with iron stone (BIF), but it also occurs in massive form in various colours from red to white.	11.5 %	10.3%	2.2 %
Basalt	A volcanic rock occurring as tholeiitic and high-Mg types in the foothills of the range. Small outcrops on the flanks of the range.	0.7 %	0.0 %	0.0 %

The most common unit within the J5 pit is Colluvium Scree (32.0 %), which is the second most common unit within the Bungalbin East pits (23.9 %) and the wider HAR (21.1 %). Goethite Mineralisation is the third most common unit at both J5 and Bungalbin East (at 14.8 % and 20.8 %, respectively), but this unit only covers a small area within the wider HAR (2.7 %).

The third most common unit within the HAR is Jasperlite rich BIF (13.8 %), but this is barely measurable at the mine pits at Bungalbin East (0.3 %) and does not occur in measurable areas within the mine pit at J5 (0 %).



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Lithology supplied by Mineral Resources (Mar 2016)
Imagery: Landgate (2012)

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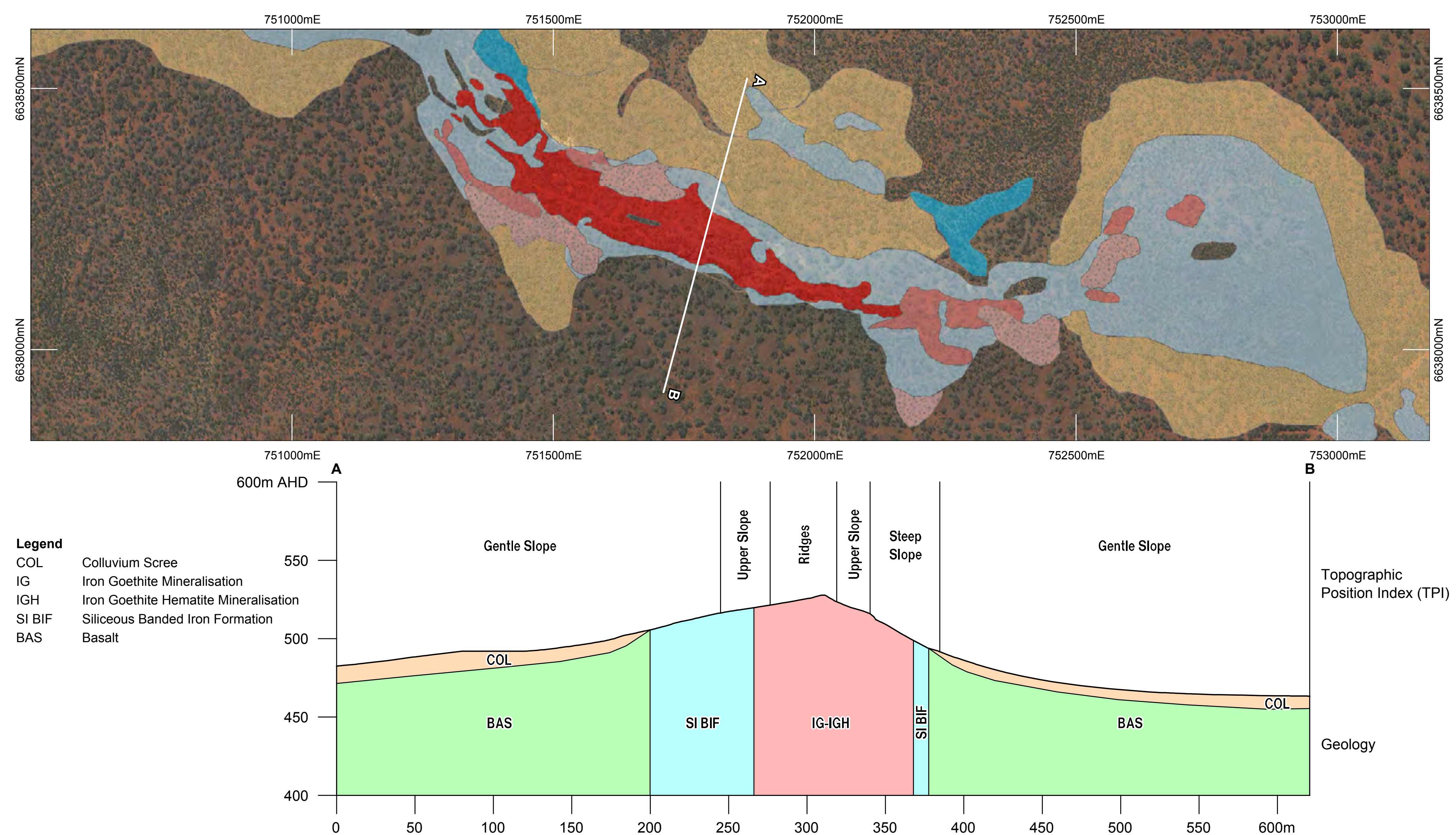
LITHOLOGY OF THE HELENA-AURORA RANGES

Figure: **6-5**



Source: Geology supplied by Mineral Resources (Jul 2016)
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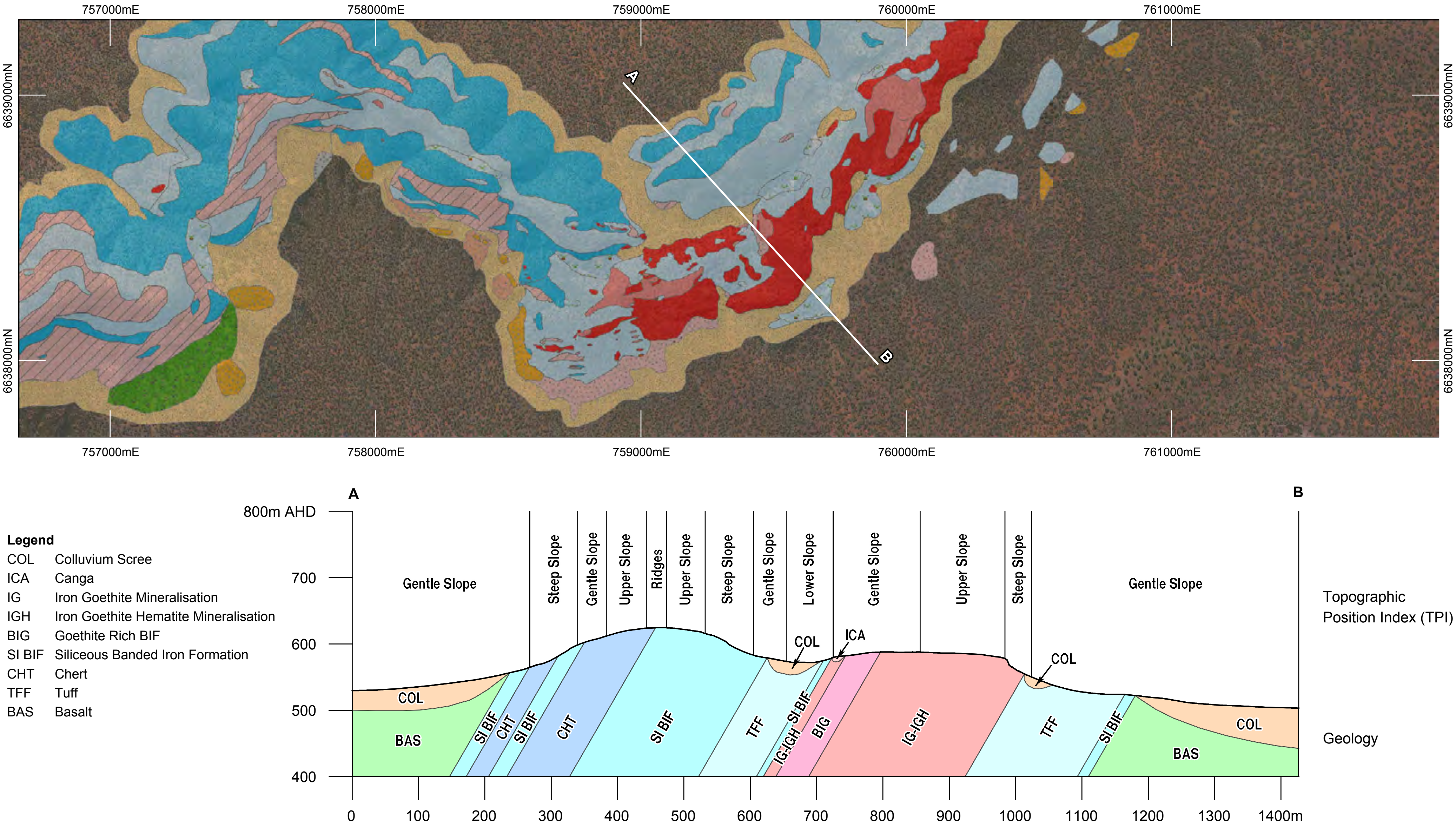
J5 GEOMORPHOLOGY (SCHEMATIC)

Figure: **6-6**



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BUNGALBIN EAST GEOMORPHOLOGY (SCHEMATIC)

Figure:
6-7

The influence of surface geology and lithology on the geomorphology of the J5 and Bungalbin East areas is illustrated as **Figure 6-6** and **Figure 6-7**.

6.2.7 Landform characteristics of the HAR

To allow comparison of the landforms within the PALs with those in the wider HAR, CAD Resources modelled data from these areas in relation to the selected landform analysis criteria (elevation, slope, aspect, TPI, Wetness Index and solar radiation). Selection of these criteria and the modelling methodology are described in **Appendix 6-A**. Key findings are provided below.

Elevation

Elevation data for the HAR, J5 pit and Bungalbin East pit are provided in **Appendix 6-A**. See also **Figure 6-8**.

Although the highest point of the HAR is 702 mAHD, only a very small portion of the range (0.3 %) occurs within the highest band of elevation (680-702 mAHD). Indeed, these data indicate that around one third of the landforms in the HAR defined by the OEPA occurs at 480-520 mAHD level (35.5 %) and around one third occur at 520-560 mAHD (30.6 %), with maximum elevations at 680-702 mAHD (0.3 %).

The landforms surrounding the J5 pit are generally of lower elevation than the wider HAR (**Figure 6-8**) with approximately 73 % of the area being 480-520 mAHD. Maximum elevations at J5 are 520-540 mAHD. In contrast, the landforms surrounding the Bungalbin East pit are generally of higher elevation than at J5, with 77.9 % of the pit area occurring at 540-640 mAHD. Of the landforms occurring in this elevation band within the Bungalbin East pit area, 29.4 % are 540-580 mAHD and 47.5 % are 580-640 mAHD. Maximum elevations are between 680 mAHD and 702 mAHD (0.5 %).

Landforms within the indicative areas of disturbance for the WRLs, roads and other infrastructure mainly occur in areas of lower elevation (**Figure 6-8**).

Slope

Slope data for the HAR, J5 pit and Bungalbin East pit are provided in in **Appendix 6-A**. See also **Figure 6-9**.

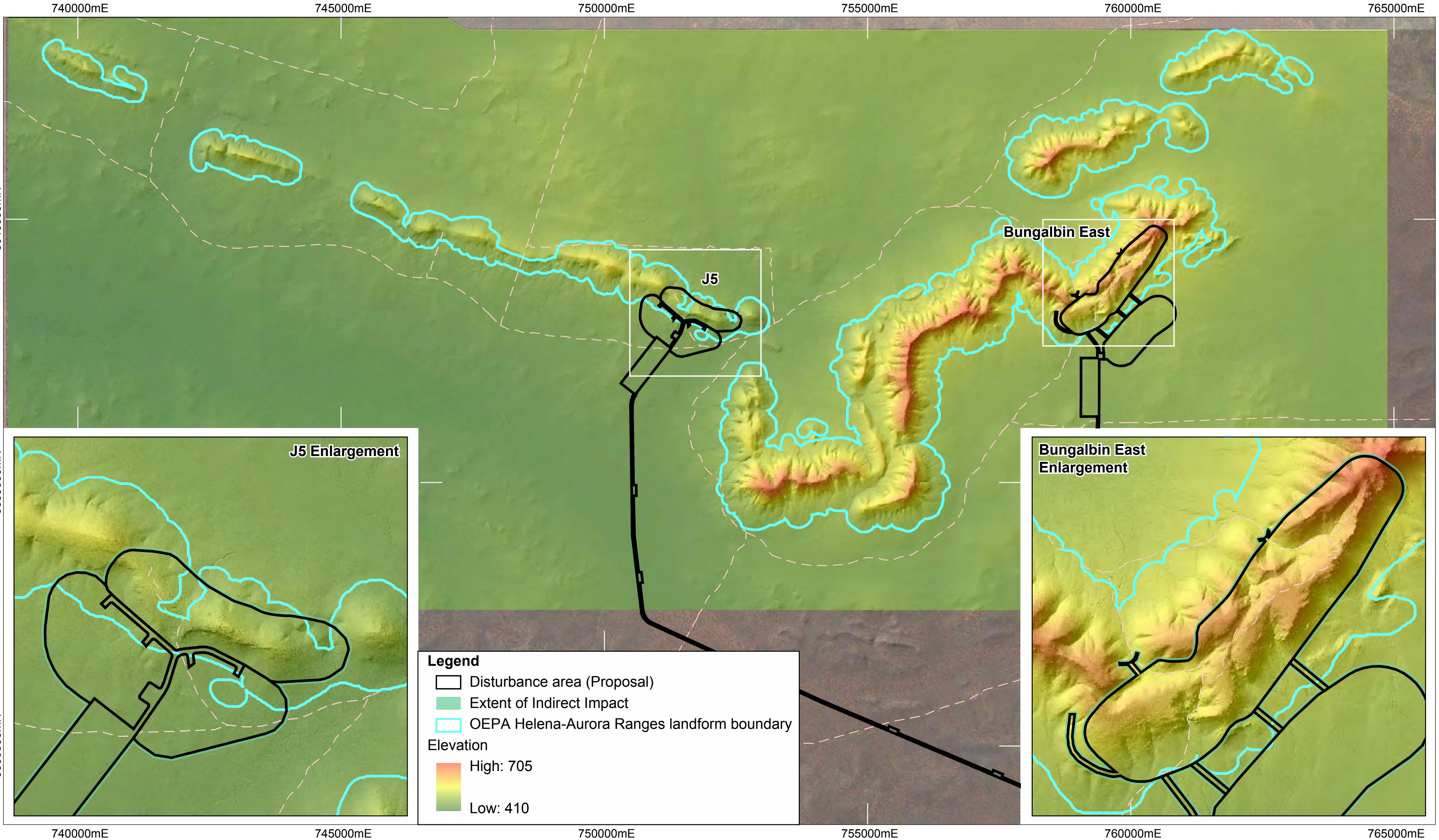
Nearly 51 % of the HAR has a slope of up to 10°, 28.7 % has a slope of 10-20° and 15.3 % has a slope of 20-30°. The Bungalbin East pit area is also characterised by slopes in these categories with 24.4 % of the area having a slope of up to 10°, nearly 35.0 % having a slope of 10-20° and 29.1 % having 20-30° slopes. In contrast, nearly 59 % of the J5 pit area has a slope of up to 10° and 35.4 % has a slope of 10-20°, but only 4.5 % of the area has a slope of 20-30°.

Landforms within the indicative areas of disturbance for the WRLs, roads and other infrastructure mainly occur in areas with more gentle slopes (**Figure 6-9**).

Aspect

Aspect data for the HAR, J5 pit and Bungalbin East pit are provided in in **Appendix 6-A**. See also **Figure 6-10**.

The aspect data indicate that the dominant aspect for these areas is south-east to south-west at 42.3 % (HAR), 53.9 % (J5) and 62 % (Bungalbin East). It is noted that 21 % of the J5 pit area has a northeast aspect, compared to 10.8 % of the HAR and 3.6 % of the Bungalbin East pit area. Landforms within the indicative areas of disturbance for the WRLs, roads and other infrastructure have variable aspects (**Figure 6-10**).



Source: Infrastructure supplied by Mineral Resources (July 2016)
Height Data generated from LIDAR Survey (Nov 2011 & Jun 2013)
Landform boundary supplied by OEPA (Sept 2015)
Imagery: Landgate (2012)

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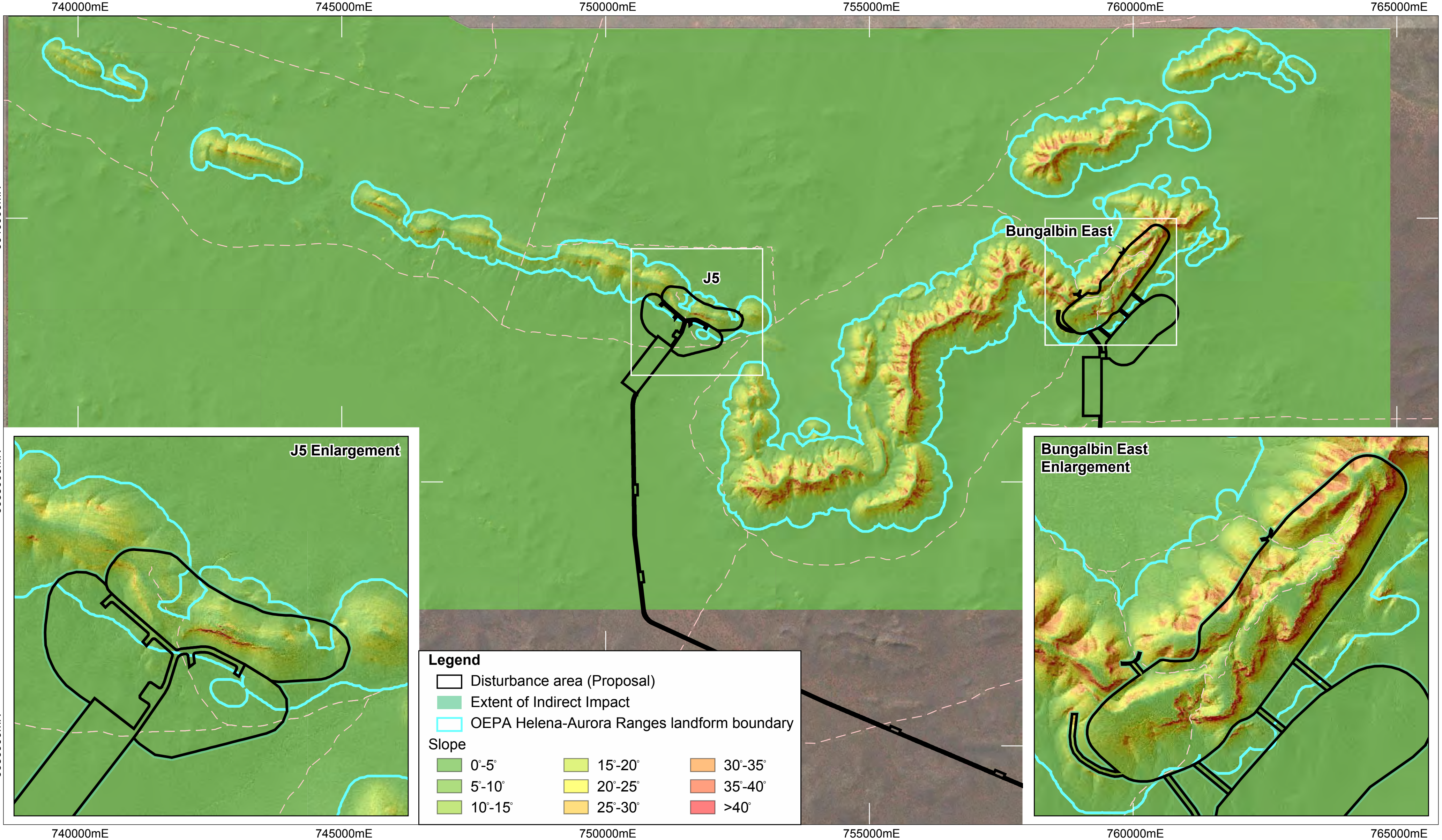
LANDFORM - ELEVATION

Figure: **6-8**



Source: Infrastructure supplied by Mineral Resources (July 2016)
Height Data generated from LIDAR Survey (Nov 2011 & Jun 2013)
Landform boundary supplied by OEPA (Sept 2015)
Imagery: Landgate (2012)

Scale 1:100,000
MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C06_F08
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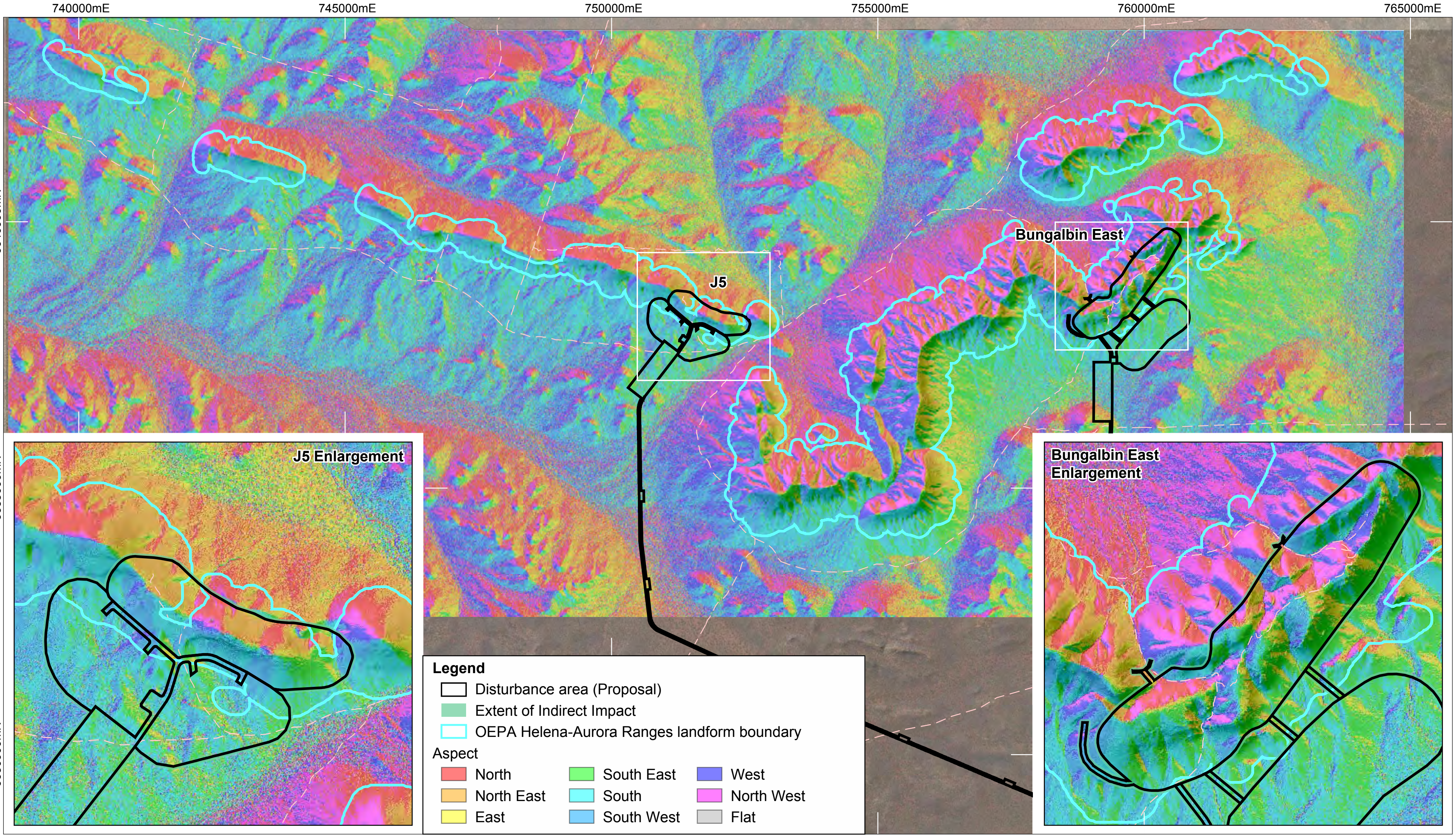
LANDFORM - SLOPE

Figure: 6-9



Source: Infrastructure supplied by Mineral Resources (July 2016)
Height Data generated from LIDAR Survey (Nov 2011 & Jun 2013)
Landform boundary supplied by OEPA (Sept 2015)
Imagery: Landgate (2012)

0 1 2km
Scale 1:100,000
MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C06_F10
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LANDFORM - ASPECT

Figure:
6-10

Topographic Position Index

Data in relation to the topographic position (or slope position) are provided in **Appendix 6-A**. See also **Figure 6-11**.

The TPI classifies the landscape into a number of categories such as Valleys, Lower Slopes, Gentle Slopes, Steep Slopes (greater than 25°), Upper Slopes and Ridges. The classification works by using the difference between a cell elevation value and the average elevation of the neighbourhood (100 m in this case) around that cell.

Positive values mean the cell is higher than its surroundings while negative values mean it is lower. The degree to which it is higher or lower, plus the slope of the cell, can be used to classify the cell into slope position. If it is significantly higher than the surrounding neighbourhood, then it is likely to be at or near the top of a hill or ridge. Significantly, low values suggest the cell is at or near the bottom of a valley. TPI values near zero could mean either a flat area or a mid-slope area, so the cell slope can be used to distinguish the two.

The data provided in **Appendix 6-A** show that the HAR is dominated by Gentle Slopes with nearly 75 % of the area falling into this category. The J5 and Bungalbin East pit areas are also dominated by Gentle Slopes (at 74.9 % and 45.5 %, respectively), but Steep Slopes (18.2 %) and Upper Slopes (18.9 %) also commonly occur with the Bungalbin East pit area.

Landforms within the indicative areas of disturbance for the WRLs, roads and other infrastructure are characterised primarily by Gentle Slopes (**Figure 6-11**).

Wetness Index

Wetness Index data for the HAR, J5 pit and Bungalbin East pit are provided in **Appendix 6-A**. See also **Figure 6-12**.

The HAR, J5 pit and Bungalbin East pit all rate low on the Wetness Index due to the high level of runoff from these areas. The lowest rankings are recorded in areas with steep slopes such as the tops of ridges, breakaways and cliff faces on the more south-facing components of the HAR (see the darker areas shown on **Figure 6-12**.

In comparison, the drainage lines adjacent to the HAR rate more highly on the index as they receive runoff from adjacent areas (see the orange-red areas shown on **Figure 6-12**).

Solar Radiation

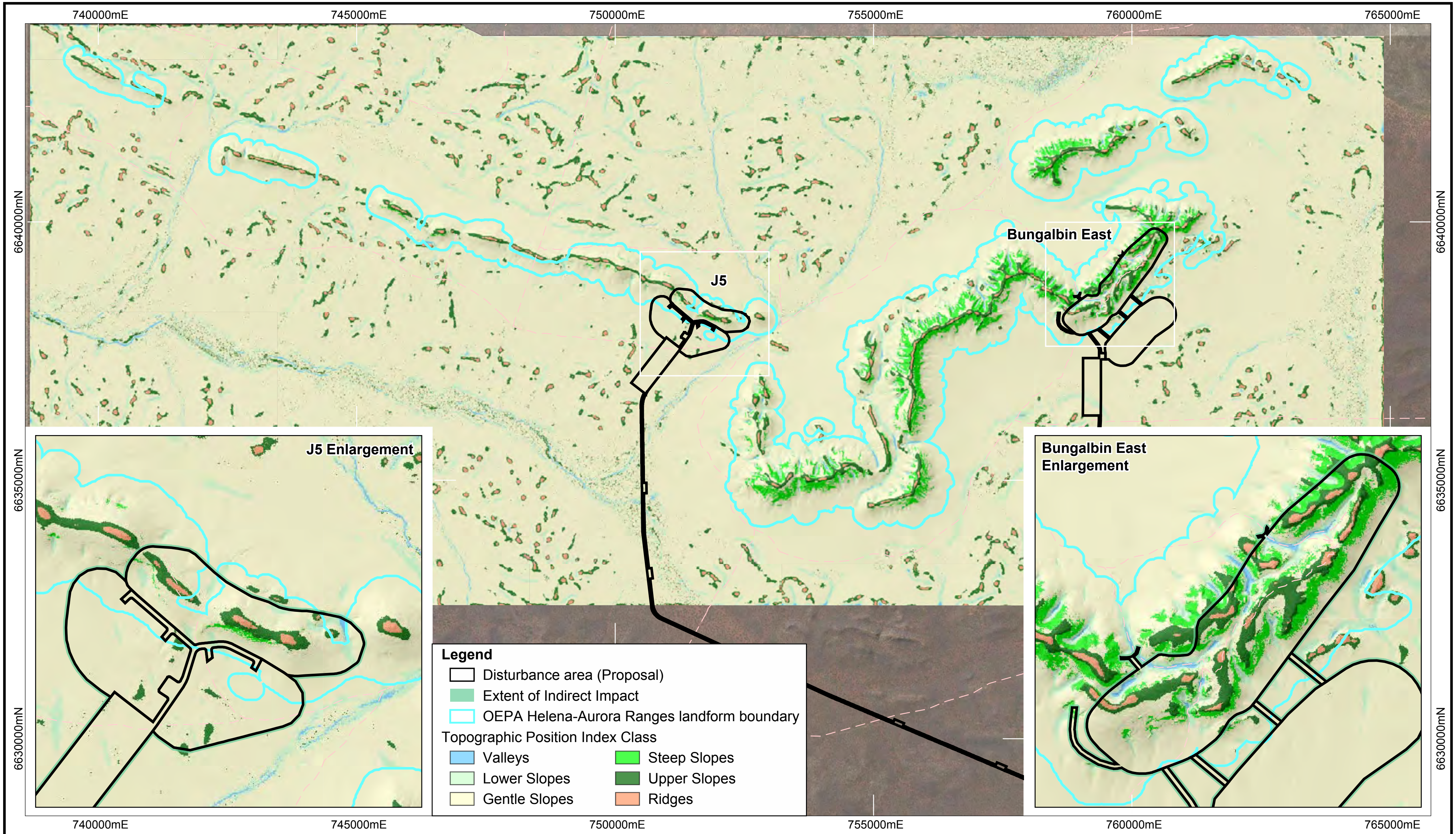
Solar radiation data for the HAR, J5 pit and Bungalbin East pit are provided in **Appendix 6-A**. See also **Figure 6-13**.

The higher levels of solar radiation are received by gentler slopes. The lowest levels are recorded in areas with steep slopes such as the tops of ridges, breakaways and cliff faces on the more south-facing components of the HAR (see the lighter areas shown on **Figure 6-11**). With their steep slopes, they receive less direct sunlight and tend to have more shadowed areas.

Landforms within the indicative areas of disturbance for the WRLs, roads and other infrastructure receive high levels of solar radiation (**Figure 6-13**).

6.2.8 Geomorphological processes

Geomorphological processes are the physical actions that create changes to landforms over time. These result in erosional and depositional features that can create new or altered landform features.



Source: Infrastructure supplied by Mineral Resources (July 2016)
Height Data generated from LIDAR Survey (Nov 2011 & Jun 2013)
Landform boundary supplied by OEPA (Sept 2015)
Imagery: Landgate (2012)

N

0 1 2km

Scale 1:100,000
MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C06_F09

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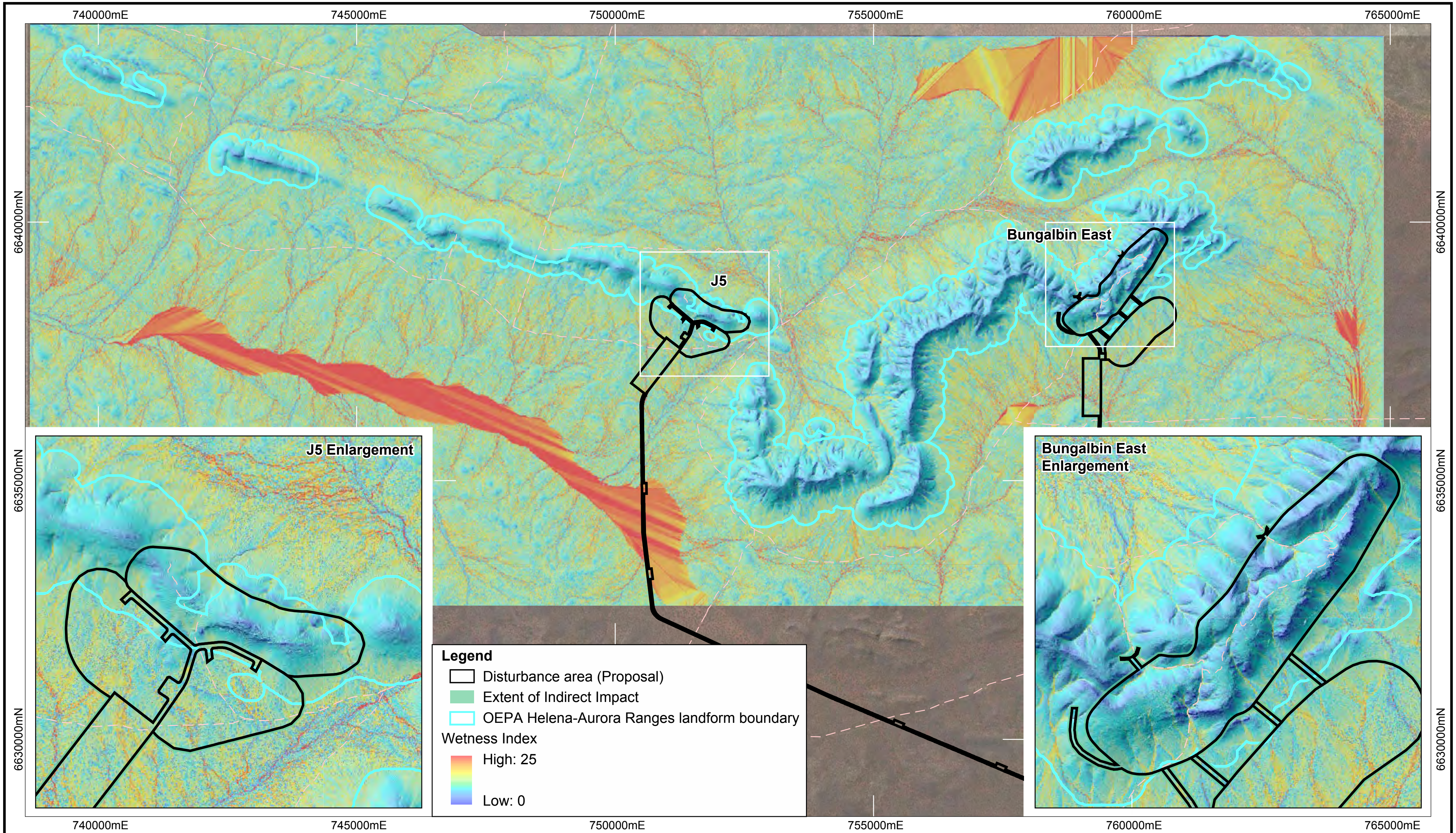
LANDFORM
TOPOGRAPHIC POSITION INDEX

Figure:
6-11



Source: Infrastructure supplied by Mineral Resources (July 2016)
Height Data generated from LIDAR Survey (Nov 2011 & Jun 2013)
Landform boundary supplied by OEPA (Sept 2015)
Imagery: Landgate (2012)

N

0 1 2km
Scale 1:100,000
MGA94 (Zone 50)
CAD Ref: g2378_J5_BE_PER_C06_F11
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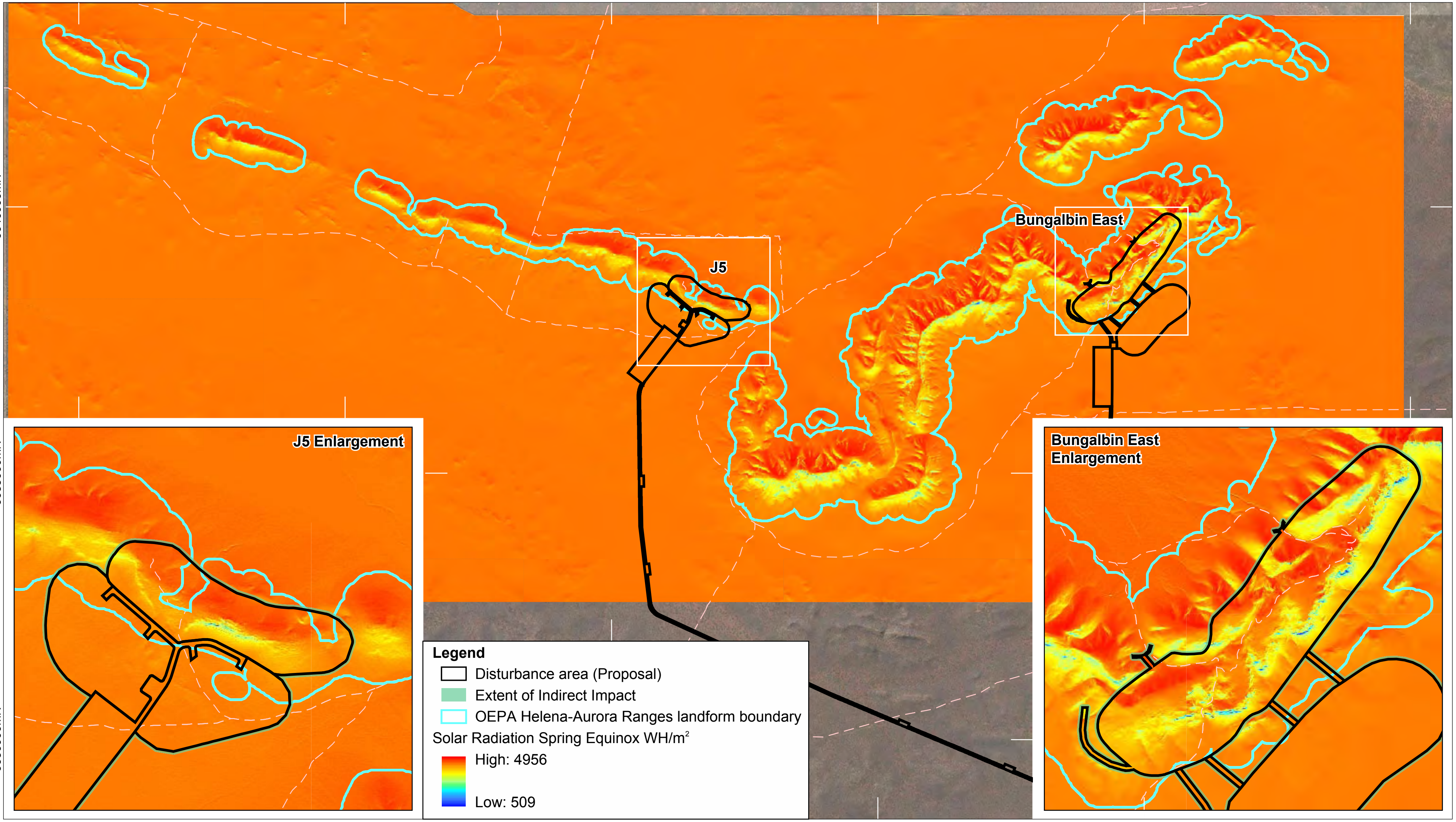
LANDFORM - WETNESS INDEX

Figure:
6-12



Source: Infrastructure supplied by Mineral Resources (July 2016)
Height Data generated from LIDAR Survey (Nov 2011 & Jun 2013)
Landform boundary supplied by OEPA (Sept 2015)
Imagery: Landgate (2012)

0 1 2km
Scale 1:100,000
MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C06_F12
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LANDFORM - SOLAR RADIATION

Figure: **6-13**

Landforms that experience the most dynamic change from geomorphological processes over a short temporal scale include braided riverbeds and coastlines, whereas the geomorphology of other landforms is usually altered over a longer time scale or as a result of anthropogenic influences on weathering, erosion, transport and deposition (Warren and French, 2001).

The main earth-surface process resulting in changes to the geomorphological features of the HAR are hill-slope processes, where the force of gravity moves soil, regolith or rock eroded from upslope to downslope areas as scree at the base of rocky slopes or colluvium material at the base of a hillslope (Whittow, 2000; Warren & French, 2001).

Fluvial and aeolian processes also playing a role in the geomorphology of the HAR. Fluvial processes can move material to the very base of the slope or deposit it in the surrounding plains as alluvium, and can transport material further than that moved by gravity alone (Warren & French, 2001). During aeolian processes, the wind is responsible for wearing away the surface and depositing wind-borne material elsewhere, usually in the form of dunes (Whittow, 2000).

Weathering, erosion, transport and deposition can occur as a result of chemical dissolution, mass movement, surface water flow, groundwater movement, wind action, wave action, glacial action, tectonic movement and volcanism (The Dynamic Nature, 2013; Sturman & Spronken-Smith, 2001). Biogeomorphological processes such as soil formation may also influence physical and chemical weathering (Sturman & Spronken-Smith, 2001).

As a geomorphological entity, the HAR represents an outcrop-controlled, largely weathering-limited feature where the pervasive bedrock outcrop and associated ridge margins convey a strong level of robustness to the terrain (K. Wyrwoll, pers. comm.). Resistance to physical and chemical weathering related to rock properties is described in **Table 6-4**. This table includes examples of rock types present at the HAR.

It has been suggested that the ridge margin colluvial slopes and associated valley/sandplain geomorphological terrains of the HAR are more sensitive to disturbances associated with the Proposal (K. Wyrwoll, pers. comm.). The soils assessment (**Appendix 12-A**) and surface water assessment (**Appendix 9-A**) conducted for the Proposal have demonstrated that the HAR is highly resistant to erosion, with erosion potential increasing at the base of the ranges and on the surrounding plains due to the finer alluvial soils.

Soil stability is controlled throughout the J5 and Bungalbin East areas by self-armouring qualities (SMU 1 and 2), *Neurachne annularis* groundcover forming an intricate network of resource accumulation and resource loss areas that decreases the effective slope length and overall velocity of any surface flows (SMU 2) and the presence of a nearly continuous cryptogam cover (SMU 3) (**Appendix 12-A**).

It is clear that geomorphological characteristics and processes strongly influence the biota of an area. Warren and French (Warren & French, 2001) state that diversity can be more efficiently maximised by selection based on geomorphological units than through survey of species. These authors state that flora and fauna species have adapted to, and therefore need, the spatial and temporal variety and scale that geomorphological processes provide (Warren & French, 2001).

Biota and biological processes (such as the influences of burrowing or tree throw on soil development) may play important roles in setting the rates of some hillslope processes (Sturman & Spronken-Smith, 2001). For example, at the HAR, cryptogam covers assist in holding the surface soils together and essentially forms a continuous crust on the surface that prevents the detachment of surface soil particles. However, if the continuity of this crust is disturbed, erosion and sediment loss increases by allowing the convergence of surface water flows and subsequent undercutting of downstream cryptogam crusts (Appendix 12-A).

6.2.9 Variety (rarity, scientific importance, ecological importance)

Rarity

The ESD for the Proposal poses a number of questions about the key aspects of variety and rarity that focus on similarity, representation and importance:

- Are the landforms considered particularly good or important examples of their type?
- How adequately are these types of landforms represented in the local or regional area?
- How do these landforms differ from other examples at these scales?
- Are the landforms rare or relatively rare; being one of the few of their type at a local and regional level?

As indicated in **Section 6.2.3**, greenstone belts of mafic volcanics and BIF are common in the northern and eastern parts of the Yilgarn Craton (Markey & Dillon, 2011a) with BIF landforms being well represented in the local and regional area (**Table 6-2** and **Figure 6-3**). BIFs and banded chert are present in all greenstone belts throughout the Yilgarn, but the silica content varies and it is this, coupled with the thickness and dip of the BIF strata, that determines the landform type.

In the HAR, the hard siliceous, moderately-dipping unmineralised BIFs have resulted in steep-sided ranges. In comparison, the Hunt Range and Yendilberin Hills have thinner, less siliceous and more shallow-dipping BIFs, which have led to more rounded, flattened hills as opposed to a prominent range that has been more resistant to weathering over time.

It is noted that the HAR and the Koolyanobbing Range are the most visually prominent features in the area mapped by Newbey (1985), with Askins (1999) contending that the BIF units at Bungalbin and elsewhere in the district are equivalent to those at Koolyanobbing.

Although BIF-dominated landforms are common throughout the Mount Manning area, data provided in **Table 6-2** indicate that the heights, maximum slopes and majority aspects of landforms in this region are quite variable. Based on available data, the HAR has a similar range of elevations compared to the Mount Manning, Mount Jackson and Die Hardy ranges.

The LiDAR data used for the detailed analysis of landform characteristics provides a highest maximum elevation of 702 mAHD for the HAR, though only 0.3 % of the HAR occurs in the 680-702 mAHD band). Other regional landforms with similar elevation ranges include Finnerty Range/Mt Dimer/Yendilberin Hills (**Table 6-2**).

The HAR has a majority aspect of 180 which means that it is predominantly south-facing. Other landforms in the region that are predominantly south-facing (i.e. within 135 and 225) include Mount Jackson Range, Evanston and Highclere Hills (**Table 6-2**). The HAR has similar maximum slopes to two of these landforms (Mount Jackson Range and Highclere Hills) and also to the Die Hardy Range, Mount Manning Range and Koolyanobbing Range (**Table 6-2**).

While BIF-dominated and other landforms in the region have many similarities in terms of physical and geochemical characteristics, there are differences in flora and vegetation, and it is in these that we find conservation importance. Numerous flora and vegetation surveys have been conducted in the HAR and wider region including, for example, ecologia Environment (2013; **Appendix 5-A**), Mattiske Consulting (2001; 2007; 2008; 2009; 2010)and Western Botanical (2009; 2013). Further, the similarities and differences of the flora and vegetation of BIF ranges have been assessed through a series of surveys conducted since the late 1990s (**Table 6-4**).

TABLE 6-4: RESISTANCE OF HAR ROCK TYPES TO WEATHERING

Rock Properties	Physical Weathering		Chemical Weathering	
	Resistant	*Non-resistant*	*Resistant*	*Non-resistant*
Mineral composition	• High feldspar content • Calcium plagioclase • Low quartz content • $CaCO_3$ • Homogenous composition	• High quartz content • Sodium plagioclase • Heterogeneous composition	• Uniform mineral composition • High silica content (quartz, stable feldspars) • Low metal ion content (Fe-Mg), low biotite • High orthoclase, Na feldspars • High aluminium ion content	• Mixed/variable mineral composition • High $CaCO_3$ content • Low quartz content • High calcic plagioclase • High olivine • Unstable primary igneous minerals
Texture	• Fine-grained (general) • Uniform texture • Crystalline, tightly packed clastics • Gneissic • Fine-grained silicates	• Coarse-grained (general) • Variable textures • Schistose • Coarse-grained silicates	• Fine-grained dense rock • Uniform texture • Crystalline • Clastics • Gneissic	• Coarse-grained igneous • Variable textural features (porphyritic) • Schistose
Porosity	• Low porosity, free draining • Low internal surface area • Large pore diameter permitting free draining after saturation	• High porosity, poorly draining • High internal surface area • Small pore diameter hindering free-draining after saturation	• Large pore size, low permeability • Free-draining • Low internal surface area	• Small pore size, high permeability • Poorly draining • High internal surface area
Bulk properties	• Low absorption • High strength with good elastic properties	• High absorption • Low strength • Partially weathered rock	• Low absorption • High compressive and tensile strength	• High absorption • Low strength • Partially weathered rock (oxide

Rock Properties	Physical Weathering		Chemical Weathering	
	Resistant	***Non-resistant***	***Resistant***	***Non-resistant***
	• Fresh rock • Hard	(grus, honeycomb) • Soft	• Fresh rock • Hard	rings, pitting) • Soft
Structure	• Minimal foliation • Clastics • Massive formations • Thick-bedded sediments	• Foliated • Fractured, cracked • Mixed soluble and insoluble mineral components • Thin-bedded sediments	• Strongly cemented, dense grain packing • Siliceous cement • Massive	• Poorly cemented • Calcareous cement • Thin-bedded • Fractured cracked • Mixed soluble and insoluble mineral components
Representative rock types at J5 and Bungalbin East	• Chert • BIF • Jasperlite • Hematite ore • Magnetite • Canga and scanga • Welded detritals • Fe cap	• Tuff • Basalt • Bedded goethite • Goethite ore • Interbedded shale and goethite	• Quartz porphyry • Jasperlite • BIF • Hematite ore • Magnetite • Scanga • Welded detritals • Fe cap	• Tuff • Bedded goethite • Goethite ore • Interbedded shale and goethite • Canga

Source: Information on mineral composition, texture, porosity, bulk properties and structure is from Lindsey et al. (1982) in Chorley et al. (1984).

A meta-analysis of the patterns across 24 of the ranges listed in **Table 6-5** conducted by Gibson et al. (2012) concluded that broad scale spatial and climatic gradients were the most important factors in explaining the variance in the richness of perennial flora species. However, Markey and Dillon (2011a) state that the high beta (β) diversity among these isolated ranges could also be attributed to a number of factors such as range-specific differences in geomorphology, historical fluctuations in palaeoclimate and stochastic processes of colonisations and extinctions within and between ranges.

BIF ranges in the Yilgarn Craton tend to support geographically restricted plant communities and exhibit high levels of endemism (Government of Western Australia, 2007; Environmental Protection Authority, 2007; Gibson, et al., 2012). They have a degree of geographic isolation from other BIF ranges and it is speculated that these ranges have acted as both refugia during drier climate cycles and centres of recent speciation (Butcher, et al., 2007a).

In their analysis of the spatial distribution of 44 ironstone specialist species, Gibson et al. (2012) found that these did not occur uniformly across the region, but were concentrated in two hot spots along the south western boundary of the Arid Zone. The eastern hot spot centres on the HAR (Gibson, et al., 2010) while the western hot spot centres on the Koolyanooka Hills (Gibson, et al., 2012).

Gibson and Lyons (2001) note that although the flora richness of the HAR is comparable to that of the Hunt Range, Watt Hills and Yendilberin Hills on Jaurdi Station (50 km east of the HAR) and Highclere Hill (100 km east-northeast of the HAR), and that there are some similarities in species composition between the ironstone floras of these ranges, there is a significant changeover of species between the range systems. This is most likely due to the smaller size of the outcrops and the more extensive development of laterite on the Jaurdi uplands, but it is possible that this has been also been influenced by a climatic gradient and Tertiary climatic history (Gibson & Lyons, 2001).

This pattern is not restricted to the HAR area. Gibson and Lyons (Gibson & Lyons, 1998a; 1998b) found that there is a marked change-over in the flora of Parker and Bremer ranges even though they have similar local underlying ecological gradients and are only 100 km apart. It is suggested that the difference between the floras of these ranges is related to regional climatic gradients (Gibson & Lyons, 1998a).

Scientific Importance

The ESD for the Proposal poses several questions in relation to scientific importance, which are addressed below in terms of geology and geomorphology, past ecological and biological processes, biological reference sites and important natural processes:

- Do the landforms provide evidence of past ecological or biological processes or are they an important geomorphological or geological site?
- Are the landforms of recognised scientific interest as a reference site or an example where important natural processes are operating?

Geology and Geomorphology

The geology of the PALs and wider region is described in **Appendix 6-A**. The influence of surface geology and lithology on the geomorphology of the J5 and Bungalbin East areas is illustrated as **Figure 6-7** and **Figure 6-8**.

As discussed in **Section 6.2.5**, much of the Yilgarn Craton has weathered into gently undulating plains overlain by deeply weathered regolith (Markey & Dillon, 2010a). BIF, however, is resistant to erosion (see **Figure 6-4**) and occurs as isolated ranges, elongated ridges and prominent hills throughout the region (Chen & Wyche, 2003).

TABLE 6-5: FLORA AND VEGETATION SURVEYS OF BIF-DOMINATED LANDFORMS

Area	Reference	Included in analysis by Gibson et al. (2012)
HAR	Gibson et al. (1997)	
Parker Range	Gibson and Lyons (1998a)	
Bremer Bay	Gibson and Lyons (1998b)	
Highclere Hills	Gibson and Lyons (2000)	
Hunt Range, Yendilberin Hills and Watt Hills	Gibson and Lyons (2001)	
Mt Manning Range	Gibson (2004)	
Yilgarn BIF ranges	Gibson et al. (2007)	
Tallering Land System	Markey and Dillon (2008a)	✓
Weld Range	Markey and Dillon (2008b)	✓
Mt Gibson and surrounding area	Meissner and Caruso (2008a)	✓
Koolanooka and Perenjori Hills	Meissner and Caruso (2008b)	✓
Jack Hills	Meissner and Caruso (2008c)	✓
Herbert Lukin Ridge	Markey and Dillon (2009)	✓
Mount Forrest – Mount Richardson Range	Meissner et al. (2009a)	✓
Cashmere Downs Range	Meissner et al. (2009b)	✓
Robinson Ranges and Mount Gould	Meissner et al. (2009c)	✓
Gullewa	Markey and Dillon (2010a)	✓
Booylgoo Range	Markey and Dillon (2010b)	✓
Brooking Hills	Meissner and Owen (2010a)	✓
Mt Ida Greenstone Belt and Mt Hope	Meissner and Owen (2010b)	✓
Western Narryer Terrane	Meissner and Owen (2010c)	✓
Perseverance Greenstone Belt	Meissner and Wright (2010a)	✓
South Illara Greenstone Belt	Meissner and Wright (2010b)	✓
Barloweerie and Twin Peaks	Meissner and Wright (2010c)	✓
Northern Yerilgee Hills	Markey and Dillon (2011a)	✓
Johnston Range	Markey and Dillon (2011b)	✓
Yalgoo	Markey and Dillon (2011c)	✓

These BIF create "islands" that support plant communities with a strong correlation to geological substrates and topo-edaphic gradients (Markey and Dillon, 2008b; Markey and Dillon, 2010a; Markey and Dillon, 2011b; Gibson et al., 2012; Meissner et al., 2009c). See also Thompson and Sheehy (2011a; 2011b; 2011c).

The literature reviewed during this study identifies a number of landform and edaphic (soil-related) factors that influence flora and vegetation distribution on BIF landforms including soil chemistry, water holding capacity, soil nutrient levels and fertility, the amount of exposed bedrock, surficial size and slope (see, for example, Gibson and Lyons, 1998a-b, 2001; Markey and Dillon, 2008a, 2011a-b; Meissner et al., 2009a-c; and Meissner and Caruso, 2008b). Within the HAR, there is a strong correlation between the distribution of vegetation types with topographic position and slope class (Gibson et al., 1997).

Within BIF sites at the Booylgoo Range, Markey and Dillon (2010b) found the greatest floristic differences between upland and lowland communities, and concluded that this is associated with extremes along a topo-edaphic gradient. This pattern is likely to occur within other BIF ranges including the HAR. Gibson et al. (2015) note that the high β-diversity across an individual range is unsurprising given the significant environmental gradients that occur between the skeletal soils on the massive BIF on the ridge tops down to the lower colluvial slopes. The high turnover in species composition between BIF ranges was much higher than expected for communities in the arid zone. Markey and Dillon (2011a) state that the high β-diversity among these isolated ranges could be attributed to a number of factors including range-specific differences in geomorphology.

In their review of the flora and vegetation or BIF landforms in the Yilgarn, Gibson et al. (2012) conclude that soil chemistry is important in relation to the distribution of the specialist ironstone species, but that it "remains unclear whether this broad scale pattern in soil chemistry is related to regional variation in rock chemistry or variation in petrological processes". Gibson et al. (2015) note that work is required to better understand the relationship of β-diversity with spatial, climate, soil chemistry and local site variables across BIF ranges. The outcomes of such studies would also better inform our understanding of the role (and therefore the importance) of geology and geomorphology of BIF landforms.

Past Ecological and Biological Processes

As stated in Chorley et al. (1984), "an understanding of the erosional and depositional processes that fashion the landform, their mechanics and their rates of operation must be obtained in order that the past evolution can be explained and the future evolution predicted". For the HAR, the role of organisms and geomorphology (biogeomorphology) is also important as flora and fauna either influence the genesis of landforms, or earth-surface processes and landforms influence the distribution of plants and animals (Whittow, 2000).

It has been speculated that BIF ranges in the Yilgarn Craton have acted as both refugia during drier climate cycles and centres of recent speciation (Butcher et al., 2007). Butcher et al. (2007) indicates that the combination of ancient relictual species and more recently diverged taxa is consistent with the biogeographical history of the Yilgarn region. These authors hypothesise that speciation processes in the region have been driven (in part) by late Tertiary-Quaternary climatic oscillations and resultant episodes of population fragmentation and genetic isolation, which have led to both old relictual taxa and relatively ancient fragmented population systems within some species complexes (Butcher et al., 2007).

This theme has also been discussed elsewhere in the literature. For example, Gibson and Lyons (1998a; 1998b) suggest that endemism at the Parker Range and Bremer Range (which have similar levels of flora endemism as the HAR) is not related to substrates, but instead suggest that the ranges may have acted as refugia during the waves of aridity during the Tertiary, which is now reflected by patterns of local endemism. A similar suggestion is made by Markey and Dillon (2011a), who state that the high β-diversity among the isolated BIF ranges of the Yilgarn could be attributed to a number of factors such as historical fluctuations in palaeoclimate and stochastic processes of colonisations and extinctions within and between ranges. Further, an analysis of the spatial distribution of 44 ironstone specialist species found that such species did not occur uniformly across the region, but are concentrated in the HAR and the Koolyanooka Hills, areas in which the evolutionary processes that lead to the distinctive ironstone flora can be conserved (Gibson et al., 2012).

Biological Reference Sites

Flora and fauna study sites from the Biological Survey of the Eastern Goldfields of WA are located within the LAU, including the HAR and surrounds (Dell, et al., 1985). See **Appendix 6-A** for further information.

Flora and vegetation surveys have been conducted on BIF-dominated landforms in the region (see **Table 6-5**). The HAR survey (Gibson et al., 1997) involved the establishment of 55 permanent plots marked with steel fence droppers. The position of these plots was recorded, but these data are not provided in Gibson et al. (1997). A schematic map of the study area indicates that two of these plots are located at J5 and several are located at Bungalbin East, and would be lost if the Proposal is implemented. Although Gibson et al. (1997) state that the results of this study support the recommendations of Keighery (1980), Henry-Hall (1990) and CALM (1994), this paper does not comment on whether any subsequent monitoring would be conducted at these plots.

Important Natural Processes

As discussed in **Section 6.2.8**, water erosion is a key mechanism in landform development, with processes such as deposition, folding and faulting also being important. BIF landforms resist erosion and occur as isolated ranges, elongated ridges and prominent hills throughout the Yilgarn region (Chen and Wyche, 2003). These “islands” support plant communities with a strong correlation to geological substrates and topo-edaphic gradients (i.e. gradients related to topography and soils). The topo-edaphic factors influencing flora and vegetation distribution and ecological function within the HAR are discussed in Appendix 6-A and the following sub-section (Ecological Importance).

Like many other semi-arid areas, the Mt Manning area is characterised by an infertile and well-sorted landscape (Morton, et al., 2011). The soils in the HAR and LAU are derived from highly weathered parent materials, are well sorted and nutrient poor.

Along the ridge line, erosion of the friable weathered surface gravels has resulted in a relatively thin layer of gravel over the solid ironstone. The thickness of the surface gravels gradually increases with increasing distance downslope due to colluvial deposition, resulting in the formation of shallow to deep gravels.

As distance downslope increases, the majority of the coarser textured particles (i.e. gravels) are deposited in upslope areas and the soils become predominately fine textured as distance downslope increases. These finer textured soils have been defined by Soilwater Consultants (**Appendix 12-A**) as SMU 3: Deep Alluvial Clays and effectively form the plain soils surrounding the outcropping BIF ridges. These soils occur throughout the Yilgarn (**Appendix 12-A**).

Ecological importance

The ESD for the Proposal queries whether the landforms “have a role in maintaining existing ecological and physical processes. For example, do the landforms have important textural features like caves, monoliths or outcropping that provide a microclimate, source of water flow or shade that support ecological functions and environmental values of the landforms?”

Geographic and climatic gradients strongly influence the floristic patterns of BIF-dominated landforms at broad scales, with key topo-edaphic features playing an important role at finer, more localised scales (see, for example, Gibson et al., 2010, and Gibson et al., 2012). These aspects are discussed below.

a) Elevation

The elevation data for the HAR, J5 pit and Bungalbin East pit provided in **Appendix 6-A** and discussed in **Section 6.2.7** indicate that the J5 pit landforms are generally of lower elevation than the wider HAR area. In contrast, the landforms within the Bungalbin East pit (in the more central part of the HAR) are generally of higher elevation. Di Virgilio et al. (2015) note that portions of the central and southwestern summits of the HAR tend to have marginally higher levels of elevation variability.

Analysis of the relationship between elevation and vegetation within the HAR by Di Virgilio et al. (2015) found a weak/negative plant-elevation heterogeneity association on northeastern summits within the HAR. This suggests that the micro-climate on these summits is less favourable to plants inhabiting these areas, possibly because these surfaces provide less protection from solar radiation. In contrast, there is a positive relationship between plant local endemism, species richness and elevation heterogeneity on the central and south-western summits (an area that includes the proposed location of the J5 and Bungalbin East pits) which suggests that there are more micro-sites that provide protection from solar radiation on these summits, possibly because a greater number of these have a southward aspect.

b) Slope and TPI

The data provided in **Appendix 6-A** and discussed in **Section 6.2.7** indicate that the J5 pit, Bungalbin East pit and the wider HAR are dominated by Gentle Slopes, though Steep Slopes and Upper Slopes are also common at Bungalbin East.

An analysis of the flora and vegetation of the HAR by Gibson et al. (1997) found that, within the HAR, there is a correlation between vegetation type, topographic position and slope class. These authors identified five broad vegetation community types within the HAR and found that Community Types 1 and 2 were restricted to the steeper slope classes. Community Type 1 occurs only on skeletal soils on massive ironstone tops and upper slopes, while Community Type 2 extends down to the midslopes where suitable outcropping of BIF occurs (Gibson et al., 1997). Community Type 3 occurs at an intermediate position in the landscape (and consequently across a broad range of slope classes) while types 4 and 5 occur low in the landscape, generally on gentle slopes and the deeper soils of the outwash plain (Gibson et al., 1997).

c) Aspect

Aspect data for the HAR, J5 pit and Bungalbin East pit are provided in **Appendix 6-A** and discussed in **Section 6.2.7**. These data indicate that the dominant aspect for these areas is south-east to south-west, though 21 % of the J5 pit area has a northeast aspect compared to just 10.8 % of the HAR and 3.6 % of the Bungalbin East pit area.

The southward aspect of many micro-sites within the HAR provides a greater level of solar protection than the north-facing aspects. It is considered that south-facing aspects will experience lower temperatures than north-facing aspects, and therefore fewer drought events (Di Virgilio et al., 2015).

d) Wetness Index and water availability

Plants require water for photosynthesis so the availability of water determines the amount of biomass produced and the rate at which it is generated, which influences the height, density and layering of vegetation (Watson et al., 2008). Plants largely access water through their roots, so the amount of water available in the substrate is critical (Watson, et al., 2008). Topography controls hydrology at a broad level by influencing drainage patterns and sediment transport. At a more local level, topographic variation influences water availability with rock fractures, fissures and depressions trapping soil and moisture (Yates, et al., 2011; Di Virgilio, et al., 2015).

The J5 and Bungalbin East pit areas rate low on the Wetness Index due to the high level of runoff from these areas (see **Appendix 6-A** and **Section 6.2.7**). Within the HAR, the lowest rankings are recorded in areas with steep slopes such as the tops of ridges, breakaways and cliff faces on the more south-facing components of the HAR (see the darker areas shown on **Figure 6-12**). In comparison, as can be seen on **Figure 6-12**, the drainage lines adjacent to the HAR rate more highly on the index as they receive runoff from adjacent areas.

The Wetness Index data provided in **Appendix 6-A** and **Section 6.2.7** show that a soil moisture gradient is in place within the indicative areas of disturbance for the Proposal and wider HAR, with upland sites having poor capacity to retain water (due to steep slopes, exposed bedrock and shallow or skeletal soils) compared to lowland sites that receive surface runoff. Higher elevation areas have better drainage than lower areas, with the sparse BIF vegetation coverage providing little impediment to surface runoff (Di Virgilio et al., 2015). The water deficit in upland areas can be compounded by aspects of microclimate such as high irradiance, extreme daily thermal variations and high rates of evaporation (Markey and Dillon, 2011a).

Rainfall in drier ecosystems such as the HAR is erratic and variable, and it is likely that there is competition between plants on the HAR for rock fractures, fissures and depressions that trap moisture (Di Virgilio et al., 2015). It is suggested by Morton et al. (2011) that soil moisture shapes the spectrum of plant life-history strategies, noting that germination and plant establishment are possible only during periods of high soil moisture. Ironstone specialist plant taxa may have a competitive advantage in such environments (Di Virgilio et al., 2015). For example, Tetratheca taxa have a leafless habit and can become dormant over extended dry periods, with new shoot growth appearing following rain (Butcher et al., 2007; Yates et al., 2011).

e) Solar radiation

The HAR is located in a semi-arid setting where slopes have shallow soil cover and experience intense solar radiation and moisture loss (Di Virgilio et al., 2015). The solar radiation data for the HAR (including the J5 and Bungalbin East pits) provided in **Appendix 6-A** and **Section 6.2.7** indicate that higher levels of solar radiation are received by the more gentle slopes than areas with steep slopes (such as the tops of ridges, breakaways and cliff faces on the more south-facing components of the HAR. See, for example, the lighter areas shown on **Figure 6 13**). With their steep slopes, they receive less direct sunlight and tend to have more shadowed areas.

Di Virgilio et al. (2015) found that the negative influence of solar radiation on flora endemism and richness was less pronounced on the central and southwestern summits of the HAR (the same areas where elevation heterogeneity has a strong, positive influence on plant richness and endemism) than the northeastern summits, suggesting that the desiccating effects of solar radiation are reduced in the latter areas. These effects would also be reduced in areas with a high number of fissures, ridges and depressions which offer protection from insolation, causing local evapotranspiration differences (Di Virgilio et al., 2015). The authors conclude that attenuation of solar radiation appears to be a key mechanism by which local elevation variability provides opportunity for ironstone flora to compete for limited sites, facilitating survival.

6.2.10 Integrity

The term 'integrity' in relation to landforms refers to the intactness, completeness or wholeness of the landforms, as well as their condition. The ESD for the Proposal poses several questions in relation to integrity:

- Are the landforms intact, being largely complete or whole and in good condition?
- To what extent have the landforms, and the environmental values they support, been impacted by previous activities or development? For example, have part of the landforms been removed?

The landforms of the LAU (**Figure 6-1**) cover an area of approximately 3,451 ha. These landforms are reasonably intact, but are not in pristine condition. It is estimated that 16.2 ha of disturbance (0.5 %) already exists across these landforms (see **Table 6-6** and **Figure 6-14**).

This disturbance within the landforms of the LAU is due to clearing and other activities associated with previous and current land use including recreation (e.g. camping), and mineral exploration. Indirect impacts (due to, for example, changes in surface drainage patterns near roads and poor waste disposal practices at camp sites) have also occurred over a slightly wider area.

6.3 Assessment of potential impacts

The ESD identifies several potential impacts and risks of the Proposal in relation to landforms:

- Loss of integrity of landforms arising from temporary or permanent structural alteration of landforms.
- Temporary or permanent reduction and/or degradation of ecological function associated with the landforms.
- Temporary or permanent degradation or loss of environmental values associated with the landforms.

6.3.1 Landform integrity

No landforms or the environmental values they support have been removed due to previous or current land use, but approximately 16.2 ha of disturbance exists within the landforms of the LAU due to clearing and other activities associated with previous and current land use such as recreation (e.g. camping), and mineral exploration (**Figure 6-14**, **Table 6-6**).

Within the HAR, Proposal implementation will increase direct disturbance of landforms to approximately 209.9 ha (6.5 %) due to pit development. Within the wider LAU area, Proposal implementation will result in direct disturbance of up to 606.45 ha.

This will comprise 207.45 ha of pits (34 %), 185.06 ha of WRLs (30.52 %) and 213.9 ha of supporting infrastructure and roads (35%). The total disturbance area of 606.45 ha comprises 1.76 % of the LAU and will increase the total area of disturbance within the LAU to around (2 %).

Predicted landform changes have been modelled in 3D and are shown in **Figure 6-15** to **Figure 6-24**. Further discussion is provided below.

TABLE 6-6: AREAS OF DISTURBANCE WITHIN THE LANDFORMS OF THE LAU

Element	Area (ha)	Impact			
		Development Envelope		Disturbance Area	
		Area	%	Area (ha)	%
Total area covered by the landforms (L1-L6)	3,451 ha	1,061.2	30.8	226.1	6.6
Estimated area of existing disturbance	16.2	-	-	-	-
Area covered by the J5 landform (L3)	495.2	178.3	36	81.3	16.4
Area covered by the Bungalbin East landform (L4)	2,157.4[1]	411.8	19.1	163.7	7.6

[1] The area for L4 includes two smaller non-contiguous landforms that have been amalgamated with the adjacent larger PAL for practical purposes

Open pits

Open pit mining will be conducted at three open-cut pits at the J5 and Bungalbin East ore deposits using conventional drill and blast techniques. The ore will be excavated, loaded and transported to the run-of-mine stockyard. At J5, this process will result in the removal of up to 75 vertical metres of rock and will produce an estimated 13-32 Mt of iron ore. The area of disturbance at the J5 pit at the completion of mining will be approximately 60.88 ha.

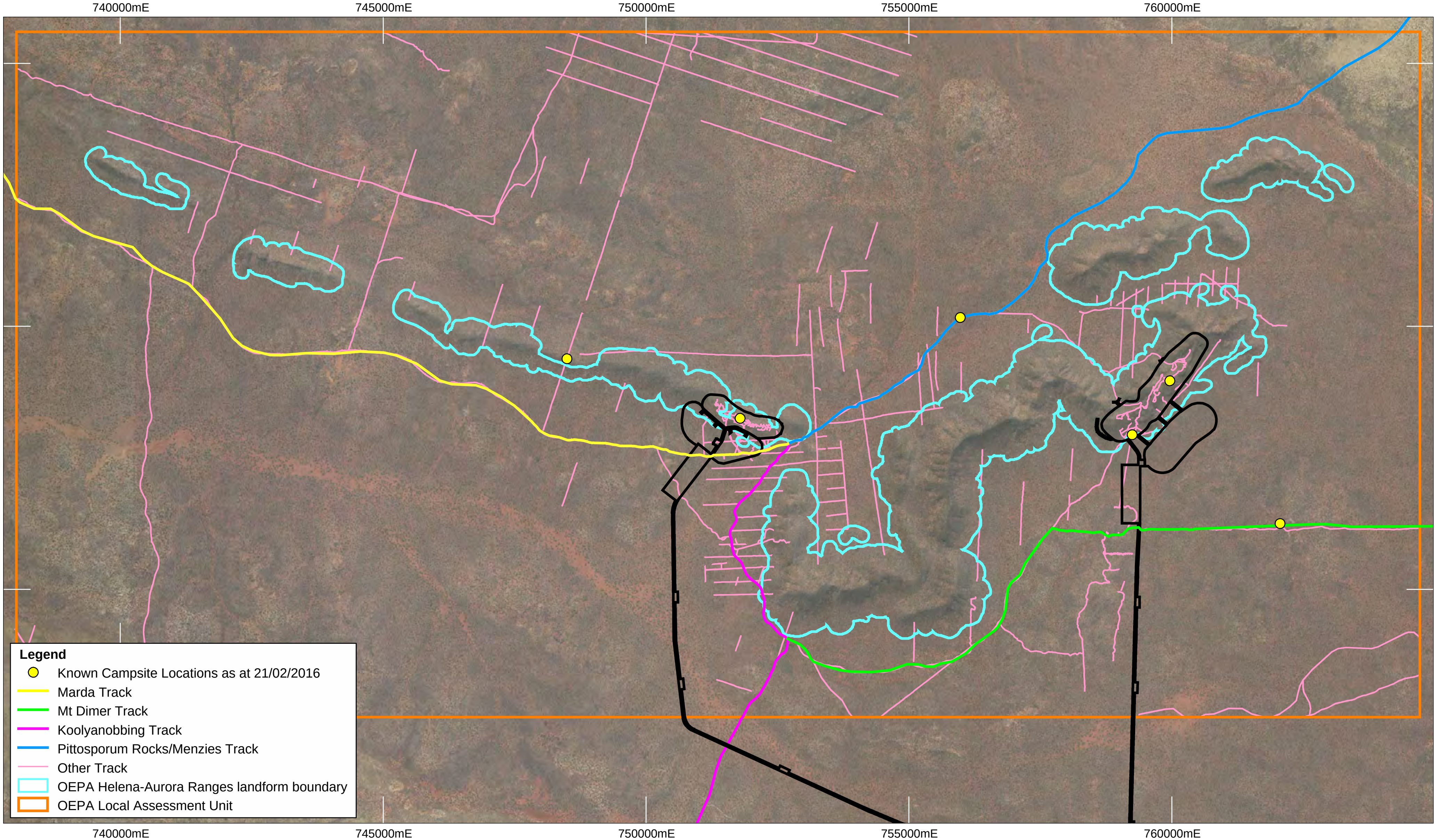
Two adjacent open-cut pits will be developed at Bungalbin East. The southern pit will be mined first and then backfilled with waste rock from the northern pit. Up to 115 vertical metres of rock will be mined within the southern (deepest) pit, but backfilling of this pit is expected to raise the pit floor to around the same height as the eastern side of the pit crest. The area of disturbance at the Bungalbin East pit at the completion of mining will be approximately 146.57 ha.

Abandonment bunds will be installed at J5 and Bungalbin East in accordance with the Department of Industry and Resources (1997) guideline for safety bund walls around abandoned open pit mines.

The areas of disturbance indicated above include locations previously disturbed by historical and current land uses, the abandonment bunds and areas required during and/or after mining for the temporary storage of cleared vegetation and harvested topsoil/subsoil that will be used for progressive and post-mining rehabilitation. They also include the light vehicle access tracks between the mine pits, vegetation stockpiles and topsoil/subsoil stockpiles.

Based on the above, it is predicted that open-pit mining within the HAR will result in localised, but permanent, alterations to the contour of the ridge lines and crests within the pit areas. Open voids will remain, but partial backfilling the southern pit at Bungalbin East and rehabilitating the backfilled area reduces the extent of this impact. The final pit floors at J5 and Bungalbin East will be above the water table, so no pit lakes will develop. Water entering these areas due to rainfall and surface runoff is expected to infiltrate the pit floors over time and should not form permanent water bodies, but may pond temporarily during cooler and wetter periods.

In addition to the direct impact on landforms of pit excavation, there is potential for direct and indirect impacts to surface drainage patterns (including changes to the direction, volume, rate and quality of surface runoff and defined flow) which could affect local landforms through alteration of erosion and sedimentation patterns. These aspects are discussed below.



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: Landgate (2012)

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0 1 2km
Scale 1:100,000
MGA94 (Zone 50)

CAD Ref: g2378_J5_BE_PER_C06_F13
Date: July 2016 | Rev: E | A4

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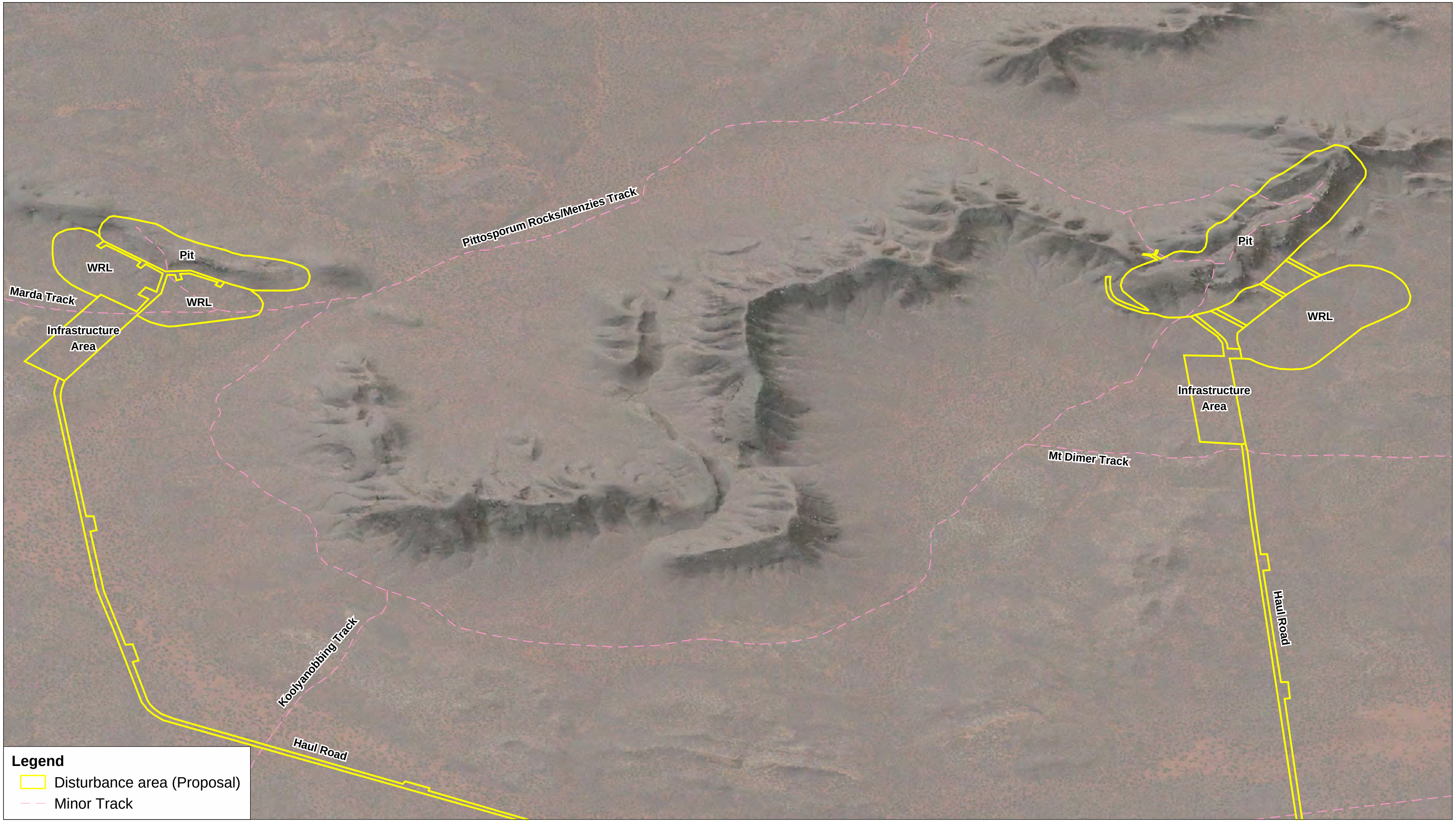
LANDFORM
EXISTING DISTURBANCE AREA

Figure:
6-14



Source: Infrastructure supplied by Mineral Resources (July 2016)
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Date: July 2016 | Rev: B | A4

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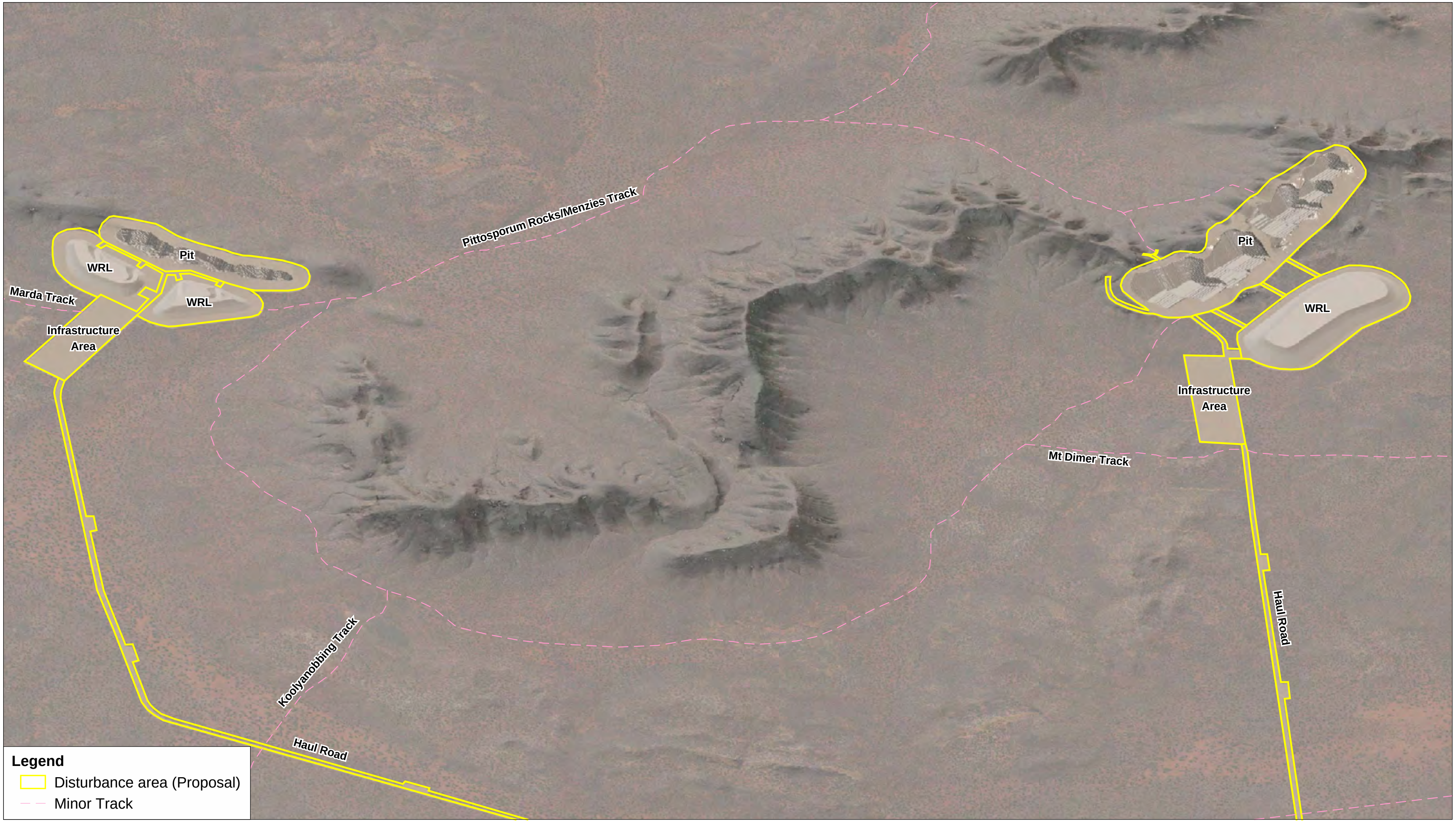
J5 & BE MINE PERSPECTIVE PRE-MINING

Figure: **6-15**



Source: Infrastructure supplied by Mineral Resources (July 2016)
Imagery: Landgate (2012)

CAD Ref: g2378_J5_BE_PER_C12_F12_02
Date: July 2016 | Rev: B | A4

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J5 & BE MINE PERSPECTIVE DURING MINING

Figure: **6-16**

Source: Infrastructure supplied by Mineral Resources (July 2016)
Imagery: Landgate (2012)

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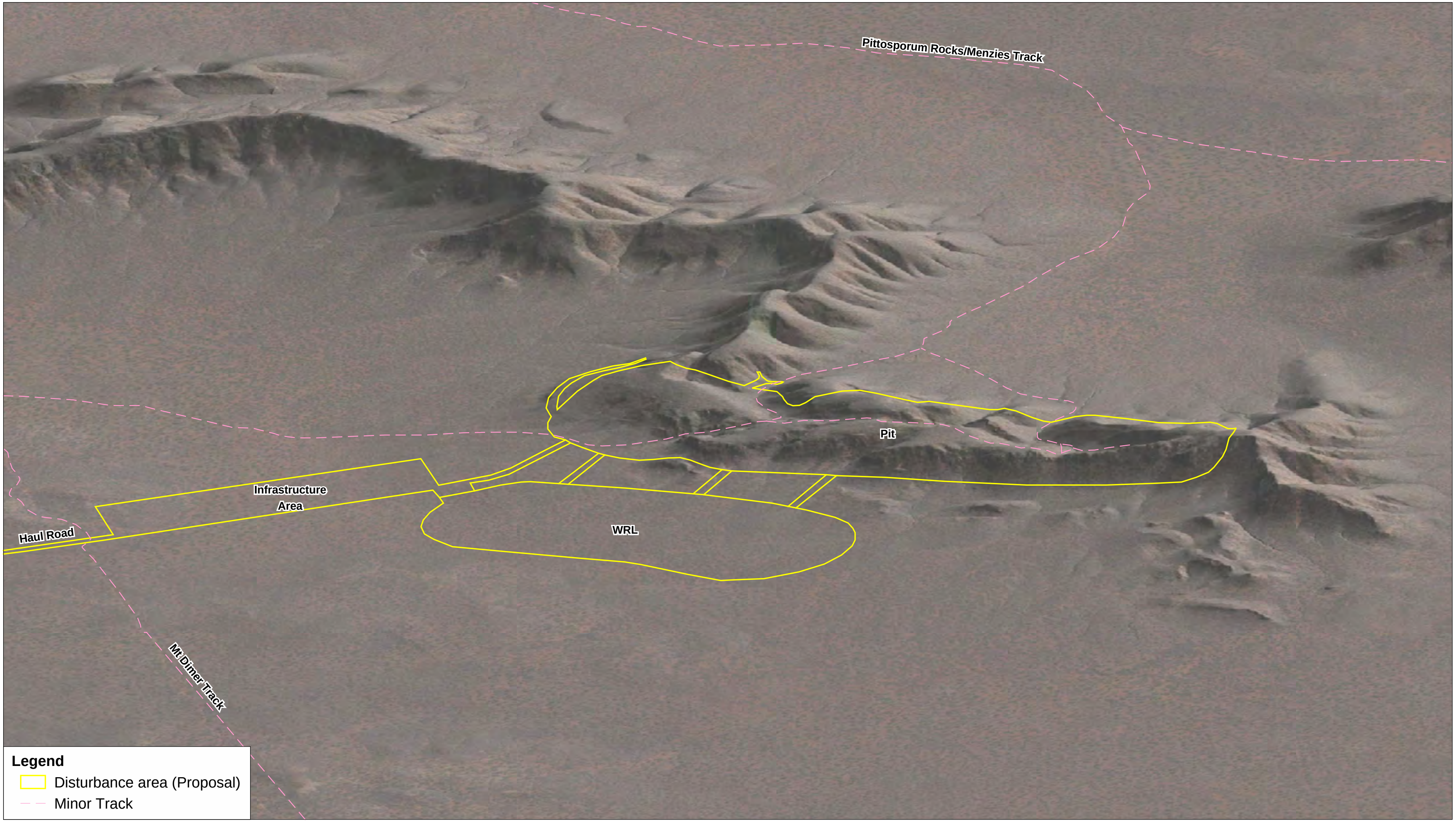
J5 & BE MINE PERSPECTIVE POST MINING

Figure: **6-17**



Source: Infrastructure supplied by Mineral Resources (July 2016)
Imagery: Landgate (2012)

CAD Ref: g2378_J5_BE_PER_C12_F12_07
Date: July 2016 | Rev: B | A4

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BUNGALBIN EAST MINE PERSPECTIVE PRE-MINING

Figure: **6-18**

Source: Infrastructure supplied by Mineral Resources (July 2016)
Imagery: Landgate (2012)

CAD Ref: g2378_J5_BE_PER_C12_F12_08
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BUNGALBIN EAST MINE PERSPECTIVE DURING MINING

Figure: **6-19**

Source: Infrastructure supplied by Mineral Resources (July 2016)
Imagery: Landgate (2012)

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Date: July 2016 | Rev: B | A4

Author: Mineral Resources
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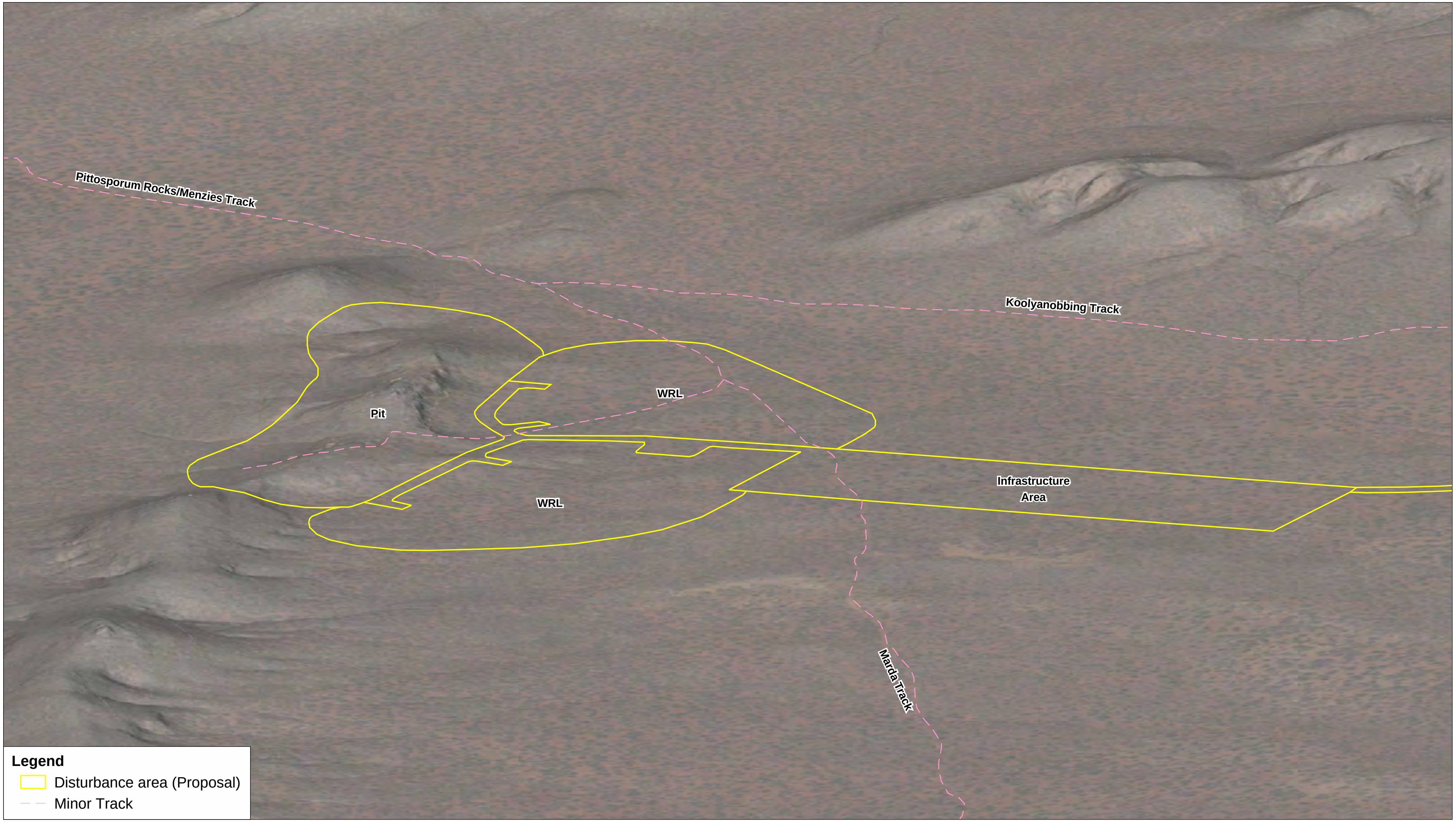
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

BUNGALBIN EAST MINE PERSPECTIVE POST MINING

Figure: **6-20**



Source: Infrastructure supplied by Mineral Resources (July 2016)
Imagery: Landgate (2012)

CAD Ref: g2378_J5_BE_PER_C12_F12_04
Date: July 2016 | Rev: B | A4

Author: Mineral Resources
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

J5 MINE PERSPECTIVE PRE-MINING

Figure: **6-21**

Source: Infrastructure supplied by Mineral Resources (July 2016)
Imagery: Landgate (2012)

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Date: July 2016 | Rev: B | A4

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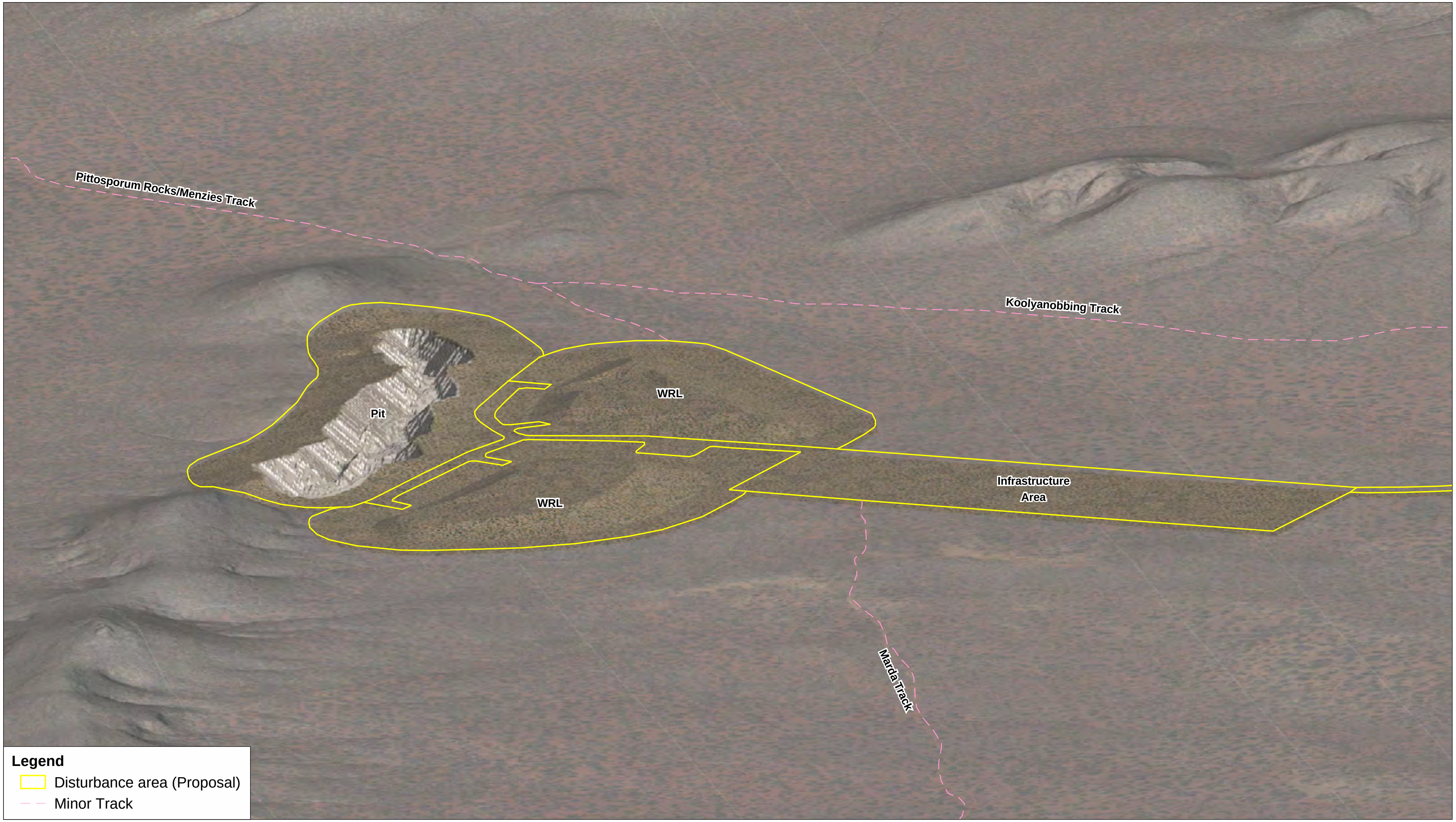
J5 MINE PERSPECTIVE DURING MINING

Figure:
6-22



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Imagery: Landgate (2012)

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Date: July 2016 | Rev: B | A4

Author: Mineral Resources
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

J5 MINE PERSPECTIVE POST MINING

Figure: **6-23**

The J5 pit area is located at a local high point along the ridge close to a valley landform. No defined drainage lines traverse the proposed pit area, with the centroid of J5 being located approximately 50 m above and approximately 1 km from the nearest delineated drainage line. Pit development will reduce the amount of surface flow reporting to this drainage line, but this will not be a significant reduction (**Appendix 9-A**). With appropriate erosion and sedimentation controls in place, there will not be a significant long term change in surface drainage direction, rate and quality as a result of pit development at J5 (**Appendix 9-A**).

The Bungalbin East pit area is located across the higher elevations of that portion of the HAR. It is located between two local catchment areas with surface run-off draining predominately away from the site to the north and south. There are no defined drainage lines in the immediate vicinity of the pit area.

Pit development may result in a minor reduction in the amount of surface runoff reporting to areas immediately downstream of the Bungalbin East pits, but with appropriate erosion and sedimentation controls in place, there will not be a significant long term change in surface drainage direction, rate and quality as a result of pit development at Bungalbin East (**Appendix 9-A**).

Waste Rock Landforms

WRLs at J5 and Bungalbin East will be developed to store up to 54 Mt of the 91 Mt of waste rock to be excavated during mining. The remaining 37 Mt of waste rock will be used to partially backfill the southern pit at Bungalbin East.

At J5, up to 21 Mt of waste rock will be stored in two WRLs adjacent to the pit. The east WRL will contain up to 10 Mt and the west WRL will contain up to 11 Mt of waste rock. These WRLs will be separated from each other and the mine pit by internal access roads. At Bungalbin East, a single WRL containing up to 33 Mt of waste rock will be developed.

Clearing of approximately 87.39 ha and 97.67 ha of native vegetation will occur in association with WRL development at J5 and Bungalbin East, respectively. These areas of disturbance include areas required during and/or after mining for the temporary storage of cleared vegetation; areas to store harvested topsoil/subsoil that will be used for progressive and post-mining rehabilitation of the WRLs; and light vehicle access tracks between the WRLs, vegetation stockpiles and topsoil/subsoil stockpiles.

Based on the information provided above, development of the WRLs will result in new raised landforms in areas that are currently flat or undulating. The landform changes will result in localised alterations to landform contours and surface drainage patterns. It is possible that these changes will cause drainage shadows to develop in downstream vegetation, but an assessment of potential shadowing effects due to altered hydrology following larger rainfall events found that impacts on downslope vegetation are unlikely (**Appendix 9-A**). WRL development may cause changes to occur in local wind patterns, Wetness Index and solar radiation, potentially influencing microclimates that could in turn affect the biota of the area. However, these impacts are expected to be highly localised in their extent.

Run-off from the WRLs may result in erosion and sedimentation but with appropriate erosion and sedimentation controls in place (see **Section 6.4.2**), and given the concave slope design for WRL closure (see **Section 6.4.3**), there will not be a significant long term change in surface drainage direction, rate and quality as a result of WRL development.

Supporting Infrastructure and Linear Corridors

The Proposal includes development of a range of infrastructure and support facilities at J5 and Bungalbin East including ore stockpile areas, site offices and workshops, laydown areas, explosive magazines, turkey nests, water supply and distribution infrastructure, waste water treatment plants, power supply, fuel storage and waste disposal areas (landfills). In addition, areas are required for the temporary storage of cleared vegetation and topsoil/subsoil for use in rehabilitation and closure works.

In addition to the infrastructure described above, the Proposal includes development of a number of haul roads and access tracks to connect the components of the mine operations within J5 and Bungalbin East, and to connect these sites to the J4 haul road. At the completion of mining, the total area disturbed by the J5 haul road will be 56.26 ha. A total area of 67.52 ha will be disturbed by the Bungalbin East haul road. This area of disturbance includes allowances for temporary storage of cleared vegetation and topsoil/subsoil for use in post-mining rehabilitation; gravel pits for supply of road-base material and the long term maintenance of unsealed mine roads; installation of v-drains, catch ponds and other drainage management measures, where required; and establishment of pipes and/or culverts where necessary to maintain surface water flow.

Development of haul roads and supporting infrastructure during Proposal implementation will generally result in minor changes to the landforms within the J5 and Bungalbin East mine areas and on the plains adjacent to the HAR due to site earthworks. These works may also result in indirect impacts such as changes to nearby surface drainage patterns, though these are expected to be localised and not significant.

The haul road corridors to the south and southwest of the J5 and Bungalbin East ore deposits follow the path of, or traverse, a number of larger surface drainage lines. Management of drainage in these areas requires special consideration which is outlined in **Section 9**.

6.3.2 Ecological function

As discussed in **Section 6.2.3** and **Section 6.2.9**, the HAR is one of a number of examples of a Yilgarn Craton BIF range. There are high levels of similarity in general geomorphological expression of the landforms that comprise these ranges, with local differences due to variations in structural geology, stratigraphy and lithology. Consequently, in terms of geomorphology-landform expression, no claim of uniqueness can be made for the HAR (K-H. Wyrwoll, pers. comm.).

While BIF-dominated and other landforms in the region have many similarities in terms of physical and geochemical characteristics, differences occur in the flora and vegetation of these landforms, as discussed in ecologia Environment (2013; **Appendix 5-A**), Mattiske Consulting (2001, 2007, 2008, 2009, 2010), Western Botanical (2009 and 2013) and the papers listed in **Table 6-5**. This is partly because of the level of geographic isolation that the ranges have from other BIF ranges (see **Section 6.2.9** for further information).

The potential impacts on flora and vegetation are assessed in **Section 5.3**, with proposed management described in **Section 5.4**. It is concluded that ecological function can be maintained within intact vegetation that will remain unaltered (see **Section 5.5**).

The vegetation of the HAR provides habitat for terrestrial fauna (i.e. vertebrate fauna and SRE invertebrate fauna), so strongly influences the distribution and habitat utilisation strategies of these components. Further information is provided in **Section 3.3**, in relation to key ecosystem processes, and **Section 8.2.1** in relation to fauna habitat. The potential impacts on terrestrial fauna are assessed **Sections 8.3** together with proposed management in **Section 8.4**. It is concluded that ecological function with respect to fauna species, populations and the overall assemblage can be maintained within fauna habitats that will remain unaltered (see **Section 8.4**).

As discussed in Warren and French (2001), the conservation of vegetation and fauna habitats must include consideration of geomorphological processes. The topo-edaphic factors influencing flora and vegetation distribution and ecological function within the HAR are discussed in **Appendix 6-A** and **Section 6.2.8** and **Section 6.2.9.** Although these processes will reduced or removed within the predicted areas of disturbance associated with the Proposal, it is expected that effective implementation of rehabilitation and closure works will allow a degree of ecological function to develop in rehabilitate areas (see **Section 6.4.3**).

Based on the above, it is concluded that ecological function of the landforms of the LAU can be maintained where vegetation and fauna habitats remain unaltered.

6.3.3 Environmental values

BIF landforms are common throughout the Mount Manning area, but the Environmental Protection Authority (2015b) states that the HAR is "considered to be one the few remaining large, intact Yilgarn BIF ranges with the highest biodiversity values". Data provided in **Table 6-2** indicate that the HAR has a similar range of elevations compared to the Mount Manning, Mount Jackson and Die Hardy ranges. There are other similarities between the HAR and other BIF landforms in the region, as discussed in **Appendix 6-A**.

While BIF landforms in the region have many similarities in terms of physical and geochemical characteristics, there are differences in flora and vegetation, and it is in these that conservation value is found. The main flora and vegetation values are described in **Section 5.2** and outlined in **Section 6.3.2**. An assessment of the potential impacts on these values is also provided in **Section 5.3**. This assessment discusses the way in which the Proposal will have a localised though significant impact on elements of the flora and vegetation of the HAR, but it is concluded that the EPA's objective for flora and vegetation can be met.

There is also conservation value associated with the terrestrial fauna of the HAR. A description of these values, and an assessment of the potential impacts on these values resulting from Proposal implementation, is provided in **Section 8**. It is concluded that the EPA's objective for terrestrial fauna can be met.

6.4 Proposed environmental management

6.4.1 Management of direct impacts

MRL has considered management actions for direct impacts to landforms in terms of open pits, waste rock landforms, and infrastructure and linear corridors (e.g. haul roads). These actions are proposed during the construction and operations phases of the Proposal. Management actions for the closure phase of the Proposal are also described.

Open pits

To minimise the potential for adverse impacts on landforms due to open-pit mining, MRL will implement a variety of actions:

- Maintain ecological and landform integrity of surrounding landforms by limiting the area of disturbance as much as possible. The company has already reduced the mine pit areas to be located on the HAR from 368 ha (as proposed in the ESD) to 207.45 ha and reduced the depth of the pits. Further, the company proposes to utilise waste rock from the northern pit at Bungalbin East to partially backfill the southern pit.
- Enforce land clearing controls.
- Controlled blasting procedures.
- Design for safe and stable pit void walls and monitor pit wall stability during mining.
- Recognise the way in which geomorphological and hydrological processes influence landform development and ecological function, and ensure that these processes are considered in closure planning for the pits.

- Install abandonment bunds (where required) outside the potential zone of pit wall instability.

Progressive rehabilitation will be conducted at the pit areas where possible, particularly with backfilling of the southern pit at Bungalbin East. The remainder of the rehabilitation will occur following the cessation of mining (see **Section 6.4.3**).

Waste Rock Landforms

To minimise the potential for adverse impacts on landforms due to development of the three WRLs, MRL will implement a variety of actions:

- Locate the WRLs adjacent to the HAR, rather than disposing of waste rock on the HAR (for example, through valley fill).
- Maintain ecological and landform integrity of surrounding landforms by limiting the area of disturbance as much as possible. The company has already reduced the WRL areas from 251 ha (as proposed in the ESD) to 185.06 ha and reduced the height of the WRLs. Utilising waste rock from the northern pit at Bungalbin East to partially backfill the southern pit has assisted in reducing the dimensions of the Bungalbin East WRL.
- Enforce land clearing controls.
- Recognise the way in which geomorphological and hydrological processes influence landform development and ecological function, and ensure that these processes are considered in closure planning for the WRLs.
- Ensure that landform design and soil management principles for rehabilitation are incorporated into the planning and operation of the WRLs.
- Undertake surface stability assessments and erosion modelling to refine slope geometry to assist in achieving long term stability.
- Erosion and sedimentation controls, where required.
- Progressive rehabilitation where possible through the life of the mine.

One of the main ways in which landform impacts can be minimised is through the implementation of effective mine rehabilitation and closure programs. A concave slope design is proposed for these WRLs to achieve a balance between constructability, size of the disturbance area and erosional stability (see **Section 6.4.3**).

Infrastructure and Linear Corridors

To minimise the potential for adverse impacts on landforms due to development of this infrastructure and these services, MRL will implement a variety of actions:

- Locating facilities away from the HAR, as much as possible.
- Maintain ecological and landform integrity of surrounding landforms by limiting the area of disturbance as much as possible. The company has already reduced the infrastructure areas from 128 ha (as proposed in the ESD) to 90.12 ha. The J5 and Bungalbin East haul road area of disturbance has also reduced slightly, from 126 ha to 123.78 ha.
- Enforce land clearing controls.
- Recognise the way in which geomorphological and hydrological processes influence landform development and ecological function, and ensure that these processes are incorporated into closure planning for these facilities.

- Ensure that landform design and soil management principles for rehabilitation are incorporated into the planning and operation of these facilities.
- Implement erosion and sedimentation controls, where required.

MRL will conduct progressive rehabilitation during the operations phase, where possible. Those facilities remaining at cessation of mining will be rehabilitated and closed in accordance with the RMCP (see **Section 6.4.3**).

6.4.2 Management of indirect impacts

Given the limited opportunities to further avoid and/or reduce the extent of landform disturbance, MRL has focussed its management efforts on indirect impacts to ensure that the impacts of the Proposal are not greater than predicted (see **Section 6.3**).

Indirect impacts to landforms will be managed through implementation of MRLs Environmental Management System for the Proposal, which includes plans and procedures relevant to the management of landforms. In addition, the following management measures are proposed:

- Implement controlled blasting procedures to minimise the potential for rock-fall outside the disturbance area.
- Design for safe and stable mine pit walls and monitor pit wall stability during mining.
- Recognise the way in which geomorphological and hydrological processes influence landform development and ecological function, and ensure that these processes are considered in mine rehabilitation and closure planning.
- Ensure that landform design and soil management principles for rehabilitation are incorporated into the planning and operation of the Proposal.
- Undertake surface stability assessments and erosion modelling to refine WRL slope geometry to assist in achieving long term stability.
- Implement erosion and sedimentation controls, where required.

6.4.3 Rehabilitation and decommissioning

The Rehabilitation and Mine Closure Plan (RMCP) developed for the Proposal (**Appendix 12-D**) states that the overall rehabilitation and closure objective is to leave the site in a safe and stable with self-sustaining ecosystems.

Progressive rehabilitation will be conducted at the pit areas where possible, particularly with backfilling of the southern pit at Bungalbin East, with the remainder of rehabilitation occurring once mining has ceased. The general Proposal area will be accessible to the public in line with the final post-mining land use.

The open pits will remain as partially or fully open voids with pit walls that may be subject to slope failures. Open voids are not usually conducive to revegetation, but where backfilling of the Bungalbin East southern pit occurs, revegetation and re-establishment of fauna habitat may be possible (**Appendix 12-D**). These works will be conducted in accordance with the RMCP and MRL rehabilitation work instructions and protocols.

A concave slope design is proposed for closure of the WRLs to achieve a balance between constructability, size of the disturbance area and erosional stability. It is considered that this design will achieve an aesthetic outcome that is more consistent with surrounding landforms than a traditional batter and berm landform design (**Appendix 12-D**).

The rehabilitated WRLs will have an average profile of 20° at the crest grading to 15° at the toe. The overall WRL slope will be 17.5°. The total constructed height is expected to be 30m, though this depends on natural ground level. The WRL slopes will be contour-ripped to provide surface roughness and decrease down-slope runoff. The top of the WRLs will back-slope to drain internally and rock armouring will be used to prevent erosion where required. Topsoil handling will be undertaken in accordance with the specifications provided in the RMCP (**Appendix 12-D**).

All infrastructure be removed and disturbed areas will be rehabilitated. Compaction will be alleviated, topsoil and subsoil will be applied, and revegetation will be undertaken (**Appendix 12-D**).

MRL will monitor rehabilitation performance and use the monitoring outcomes to modify rehabilitation and closure programs where required (**Appendix 12-D**).

Climate Change Prediction Maps for WA have been prepared by the Department of Agriculture and Food (2007) and projections for changes in monthly temperatures and rainfall for 2030 and 2070 for key Australian mineral provinces have been developed by CSIRO (Loechel et al., 2010). Based on these projections, it appears that mine closure planning for the Proposal needs to consider the likely performance and sustainability of the final landforms under regional conditions characterised by higher average annual and maximum temperatures, lower annual average rainfall, more frequent and more severe periods of drought, and more frequent and more severe storm events. However, MRL has adopted conservative design criteria in its closure planning for the Proposal, so additional allowance for climate change is not required.

6.5 Residual impact

The residual impact on landforms comprises direct impacts due to mining excavation and WRL development (altered landforms) and indirect impacts such as altered surface drainage patterns in localised areas.

Localised but permanent alterations to the contour of ridge lines and crests will occur to L3 and L4 (the PALs) as the result of mine pit development having a total area of 207.45 ha. Open pit voids will remain and will have walls that may be subject to slope failures and will not be conducive to revegetation. However, these will affect a small area of the landforms of the LAU (6%), so the extent of the impact on the integrity of the landform within these areas will also be limited.

New landforms (WRLs) will be developed over a total area of 185.06 ha adjacent to the HAR. These will result in localised alterations to landform contours and surface drainage patterns. It is unlikely that these changes will cause drainage shadows to develop in downstream vegetation (**Appendix 9-A**). These landforms may also cause changes to occur in local wind patterns, wetness index and solar radiation, potentially influencing microclimates that could in turn affect the biota of the area. These impacts, however, are expected to be localised. Effective rehabilitation of the WRLs will facilitate the return of some ecological function to these new landforms and reduce the extent of these impacts in the long term.

It is concluded that the residual impact due to the small area of additional disturbance within the landforms of the LAU (which will increase from 0.47 % to 6.48 %) is not considered to be significant as ecological function can be maintained in adjacent areas.

6.6 Predicted outcome

The EPA objective for landforms is to maintain the variety, integrity, ecological functions and environmental values of landforms. This section evaluates whether the Proposal can meet this objective, having specific regard to the HAR and the LAU defined for the Proposal.

The HAR provides an example of a BIF landform within a region in which these types of landforms are well represented at a local and regional scale. BIF landforms are common throughout the Mount Manning area. Although the HAR has the highest maximum elevation at 702 mAHD, this only occurs in a very small portion (0.3 %) of the range that is not proposed to be disturbed, with approximately 66 % of the HAR occurring in the 480 – 560 mAHD. A similar range of elevations occurs at a number of the regional landforms listed in **Table 6-2** including the Mount Manning, Mount Jackson, Finnerty Range/Mt Dimer/Yendilberin Hills, and Die Hardy ranges.

There are other similarities within the regional landforms. Based on available data (**Table 6-2**), the HAR has similar maximum slopes to the Mount Jackson Range, Die Hardy, Mount Manning Range, Koolyanobbing Range and Highclere Hills. Further, the HAR has a majority aspect to that of the Mount Jackson Range, Evanston and Highclere Hills which are generally south-facing landforms.

The iron content of the regional BIF landforms tends to vary, as does the silica content, and this can influence the steepness and other characteristics of these ranges and hills. The BIF unit within the PALs is equivalent to that at Koolyanobbing (Askins, 1999) and has high levels of iron and silica which are more resistant to weathering than other rock types. Consequently, a steep sided range has developed which is similar to a number of ranges in the region, but different to the more rounded and flattened ranges that comprise the Hunt Range and Yendilberin Hills.

All of the lithological units mapped within the J5 and Bungalbin East pit areas occur within the landforms elsewhere in the LAU. There are differences between the J5 and Bungalbin East pit areas (e.g. the J5 pit is characterised by Gentle Slopes at a generally lower elevation than the Bungalbin East pit area), but the landforms (hills and plains) affected by Proposal implementation are well represented throughout the landforms of the LAU.

No landforms have been removed from the HAR, but surface disturbance is present within these landforms. This means that the HAR is largely complete and in relatively good condition, but is not pristine. The additional disturbance as a result of the Proposal is small relative to the extent of the landforms within the LAU. The Proposal will increase the disturbance area by 6.01 % to 6.48 %. This does not represent a significant impact on the integrity of the landforms.

BIF landforms in the Yilgarn are resistant to erosion so tend to occur as isolated ranges, elongated ridges and prominent hills. These landforms have a degree of geographic isolation from other BIF ranges and it has been suggested that these ranges have acted as both refugia during drier climate cycles and centres of recent speciation (Butcher et al., 2007). The natural processes operating in the landforms of the LAU are likely to be the same or similar to those operating at other BIF landforms in the region, but there are differences in flora and vegetation.

BIF landforms tend to support plant communities with a strong correlation to geological substrates and topo-edaphic gradients (i.e. gradients related to topography and soils). The role of topo-edaphic factors in influencing flora and vegetation distribution and ecological function within the HAR is discussed in Di Virgilio et al. (2015) and **Appendix 6-A**.

A number of factors are identified and discussed, including elevation, slope and TPI, aspect, Wetness Index and water availability, and solar radiation. Given the small area of the HAR that will be disturbed through Proposal implementation, and the way in which the landforms within the PALs are replicated across the HAR, it is concluded that ecological function within the HAR and LAU can be maintained where vegetation and fauna habitats remain unaltered.

On the basis of the above information on local and regional landforms, it is considered that the HAR is not rare or one of a few of its type. Consequently, it is considered that the variety of local and regional landforms can be maintained with Proposal implementation.

In summary, the disturbance arising from the Proposal is small relative to the extent of the both the HAR. Further, the affected landform values are represented elsewhere across the HAR and wider MMHARCP.

Therefore, the Proposal can meet the EPA's objective in relation to Landforms to maintain the variety, integrity, ecological functions and environmental values of landforms.

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7. SUBTERRANEAN FAUNA

7.1 EPA objective and policies

The EPA objective for subterranean fauna is:

- To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.

The policy and guidance documents referenced as part of the field investigations and impact assessment are provided in **Table 7-1**. This PER is consistent with all policy and guidance documents referenced therein.

TABLE 7-1: LEGISLATION, POLICIES AND GUIDANCE CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
EPA (2013) Environmental Assessment Guideline 12: Consideration of subterranean fauna in environmental impact assessment in Western Australia. Perth, Western Australia.	Explains how subterranean fauna are considered in EIA, recognising the difficulties associated in the context of limited knowledge. It provides advice to proponents on the level of information and survey required, and how to analyse the results as part of the EIA process using potential habitat as a basis.	**Appendix 7-A** outlines the approach to subterranean fauna surveys completed, as summarised in **Section 7.2**. The approach is consistent with the guidelines. Impact assessment considers available habitat (PER **Sections 7.2.1**, **7.2.2** and **7.3.1**).
EPA (2007) Draft Guidance Statement No. 54a: Sampling methods and survey considerations for subterranean fauna in Western Australia. Perth, Western Australia.	Outlines acceptable sampling efforts and methodologies for subterranean fauna. This guidance remains in draft form and supplements EAG 12 (above).	**Appendix 7-A** outlines the general approach to survey, summarised in PER **Section 7.2**, and is consistent with guidance.
Conservation and Parks Commission (2014) Position Statement No. 11: The Protection of Surface and Groundwater Biodiversity Values of Lands Vested in the Commission.	Outlines the surface and groundwater biodiversity values that are significant to the Conservation and Parks Commission; the principles of avoidance, mitigation and offsets and the consultation requirements.	**Appendix 7-A** assesses the potential impact to stygofauna from the Proposal, summarised in PER **Section 7.2**, and is consistent with the Position Statement.
EPA Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity	Provides the basis for consultants and proponents to screen the quality of their EIA documents. It defines the minimum standard for the key elements of EIA documentation to be submitted.	All relevant items completed in relation to subterranean fauna and provided to OEPA.

This PER has been prepared to be consistent with all policy, guidance documents and position statements referenced in **Table 7-1**.

7.2 Subterranean fauna assessment

Subterranean fauna assessments of the Helena-Aurora Range (HAR) were undertaken by ecologia Environment (2014b) and Bennelongia Environmental Consultants (**Appendix 7-A**). The latter assessment was undertaken in response to a request from DPaW for additional characterisation of the subterranean fauna assemblages of the area, beyond that provided by ecologia Environment (2014), to be undertaken.

The Bennelongia Environmental Consultants (**Appendix 7-A**) assessment comprised a desktop assessment of stygofauna as well as field survey in 2015 for troglofauna. In addition, the assessment complements previous subterranean fauna sampling for both stygofauna and troglofauna undertaken since 2007:

- Helen-Aurora Range (overlapping) (ecologia Environment, 2014b; Bennelongia Environmental Consultants, 2008a)
- Jackson Range, located 41 km W (ecologia Environment, 2014b; Wetlands Research & Management, 2008a; 2009)
- Koolyanobbing Range, located 53 km S (Bennelongia Environmental Consultants, 2008b)
- Windarling Range, located 54 km NNW (Wetlands Research & Management, 2008b)

A full copy of the results of the 2015 field survey of the HAR and assessment of the conservation significance of its subterranean fauna is provided in **Appendix 7-A**.

7.2.1 Stygofauna

Stygofauna are aquatic animals that live in groundwater and although rich communities of these animals have been documented from calcrete bodies in paleo-valleys of the Yilgarn, few species have been recorded from other geological formations such as BIF ranges (**Appendix 7-A**).

Stygofauna surveys of the nearby Mt Jackson J1 and Windarling W2 deposits over the period 2006-2008 did not record any species and it was concluded that both areas were unlikely to support stygofauna (Wetlands Research & Management, 2008a; 2008b; 2009). Surveys at the nearby Mummaloo and Carina deposits (Bennelongia Environmental Consultants, 2009; 2012) also did not record any species although some fragments thought to be stygofauna were retrieved, some of which were later concluded to be contaminants (**Appendix 7-A**).

The desktop review undertaken by ecologia Environment (2014b) prior to survey of the HAR listed a single stygofaunal species as known from the vicinity. This is an undetermined species of harpacticoid copepod, a group that is diverse in aquifers throughout WA and contains wide-ranging as well as range-restricted species (**Appendix 7-A**). The harpacticoid species was collected as by-catch during a troglofauna survey of the Regional Yilgarn Project (Rockwater Pty Ltd, 2009).

It is concluded that the fractured rock aquifers at J5 and Bungalbin East will not contain a significant assemblage of stygofauna because previous surveys of similar aquifers in the region have not produced any evidence of stygofauna occurrence (**Appendix 7-A**), thus a field survey is unnecessary.

7.2.2 Troglofauna

Troglofauna are air-breathing animals that occur in the vadose zone (i.e. between the deeper soil layers and the watertable) (see Halse and Pearson (2014)).

Whether troglofauna occur in an area is dependent on the availability of subterranean habitat containing suitable-sized spaces, such as the vugs and small voids that occur in weathered rock and the interstitial spaces in scree and coarse colluvium. These spaces need an indirect connection to the surface for the supply of energy and nutrients. The extent of occurrence of subterranean spaces can be inferred with moderate accuracy from the geology of the area.

Data in the public domain suggest that, in general, troglofauna communities in ranges of the Yilgarn are less rich than in the Pilbara. Nevertheless, some surveys in ironstone at the Koolyanobbing Range, Mount Jackson Range, Hunt Range, Mt Dimmer, Yendilberin Hills and Mummaloo have documented moderately developed troglofauna associations (Bennelongia Environmental Consultants, 2008a; 2008b; 2009; 2012). While predictions are uncertain, sampling results from the above areas suggest that mineralised BIF at J5 and Bungalbin East is prospective for troglofauna.

Troglofauna sampling occurred in the Proposal disturbance area in 2007, 2008, 2012, 2013, and 2015 in compliance with the general principles laid out for subterranean fauna sampling in Environmental Assessment Guideline 12 (Environmental Protection Authority, 2007) and Guidance Statement 54a (Environmental Protection Authority, 2013).

7.2.3 Geology

The Proposal area is comprised of low ridges of discontinuous outcropping BIF units, striking in a general northwest (J5)-southeast (Bungalbin East) direction, that rise up 150-200 m above the surrounding sandy plains (**Figure 7-1**).

At the J5 deposit in the Jackson Range, bedded goethite mineralisation/BIF and mineralised canga outcrop occur along a strike length of 680 m with an average width of 100 m. The Bungalbin East deposit in the HAR is larger with a strike length of approximately 2.5 km and an average width of approximately 150 m. Target mineralisation at Bungalbin East is also goethite mineralisation and mineralised canga.

7.2.4 Field and habitat assessment

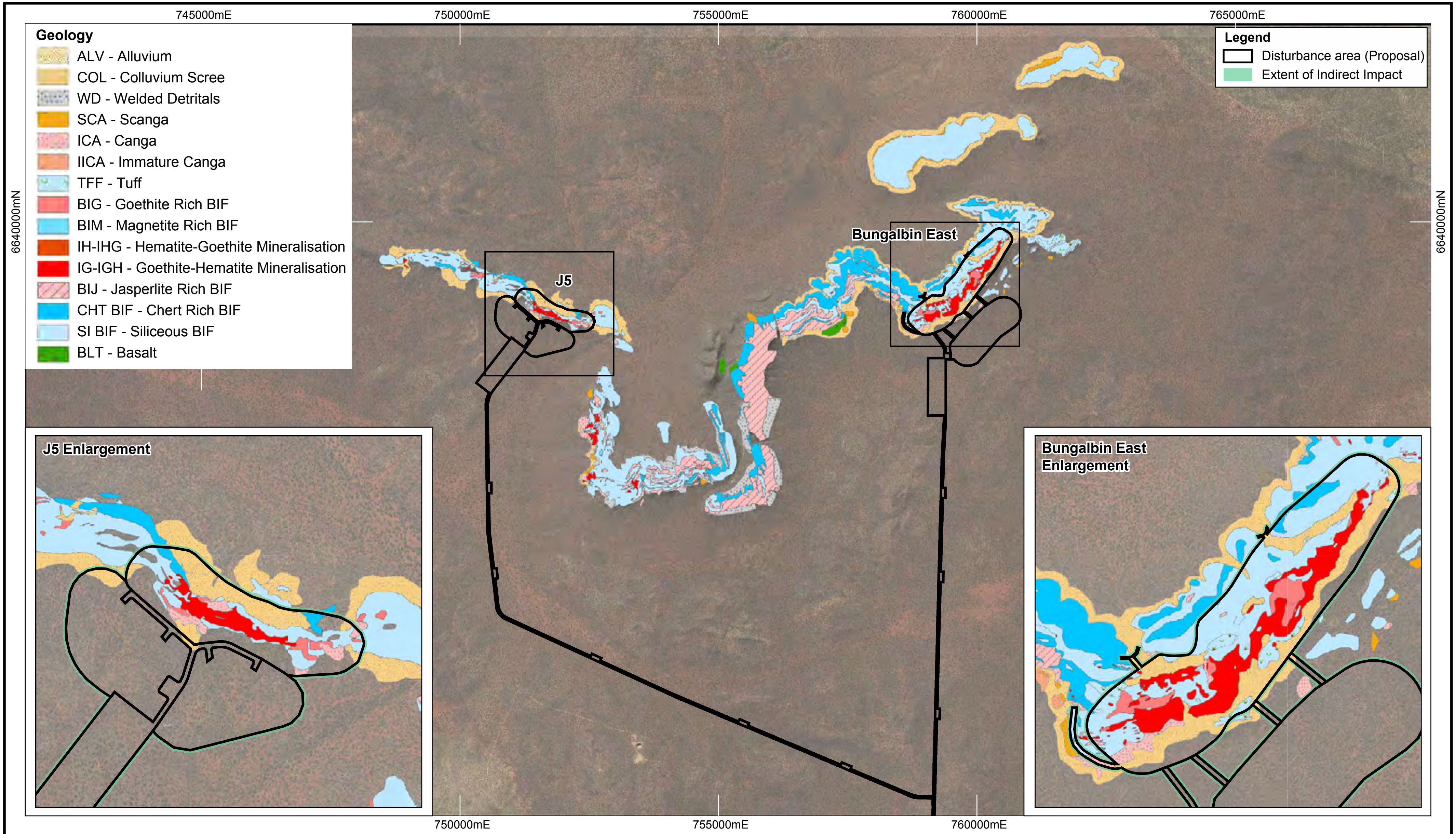
Troglofauna surveys occurred between 2007 and 2015 using two sampling techniques – scraping and trapping. The overall survey effort is summarised in **Table 7-2** and mapped in **Figure 7-2**. Regional sampling locations are shown in **Figure 7-3**.

It should be noted that for the purposes of calculating survey effort in the Proposal disturbance area, one sample comprises both a scrape and one or two traps samples. Twelve holes were sampled at Bungalbin East within the proposed disturbance area and 41 holes were sampled at J5. A single drill hole at Bungalbin Central and represents the only reference site available.

The total sampling effort at J5, Bungalbin East and Bungalbin Central deposits during all years of survey has yielded 57 troglofauna specimens of nine orders and 16 species (**Table 7-3**). This includes:

- one order of arachnids (Araneae: 2 species)
- one order of crustaceans (Isopoda: 4 species)
- two orders of centipede (Geophilida: 1 species; Scolopendrida: one species)
- one order of pauropoda (Tetramerocerata: 2 species)
- one order of symphyla (Cephalostigmata: 2 species)
- three orders of hexapods (Entognatha/Insecta) - Diplura (1 species), Thysanura (1 species), and Coleoptera (2 species).

Details of species collected and alignment with species names used in 2015 and earlier surveys are provided in **Appendix 7-A**.



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Lithology supplied by Mineral Resources (Mar 2016)
Imagery: Landgate (2012)

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CAD Ref: g2378_J5_BE_PER_C07_F01
Date: July 2016 | Rev: B | A4

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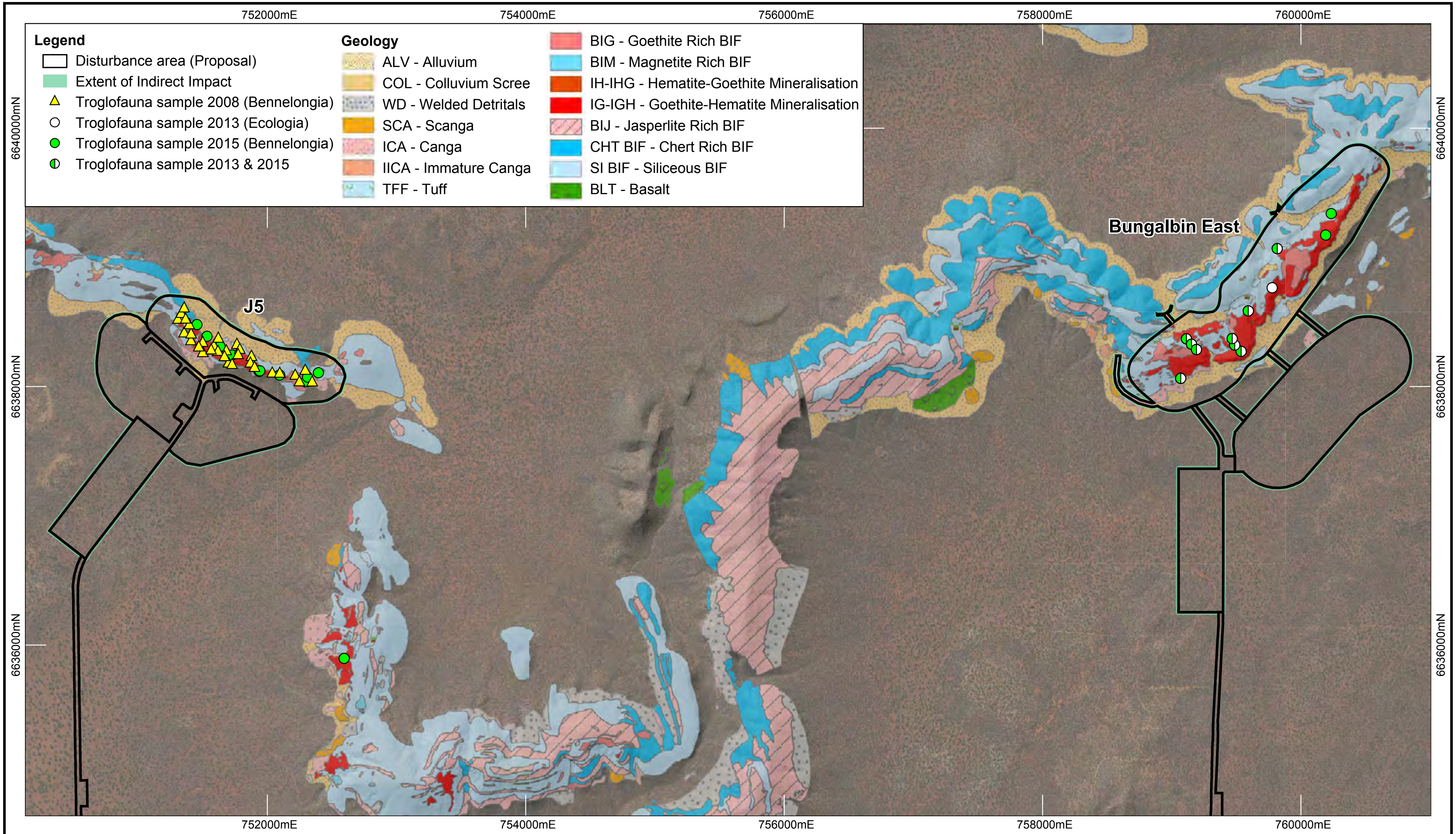
GEOLOGY OF THE MT JACKSON AND HELENA AURORA RANGES

Figure: **7-1**



Source: Infrastructure supplied by Mineral Resources (July 2016)
Sample Sites supplied by Bennelongia Env. Cons. (July 2016)
Imagery: Landgate (2012)

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Date: July 2016 | Rev: C | A4

Author: Mineral Resources
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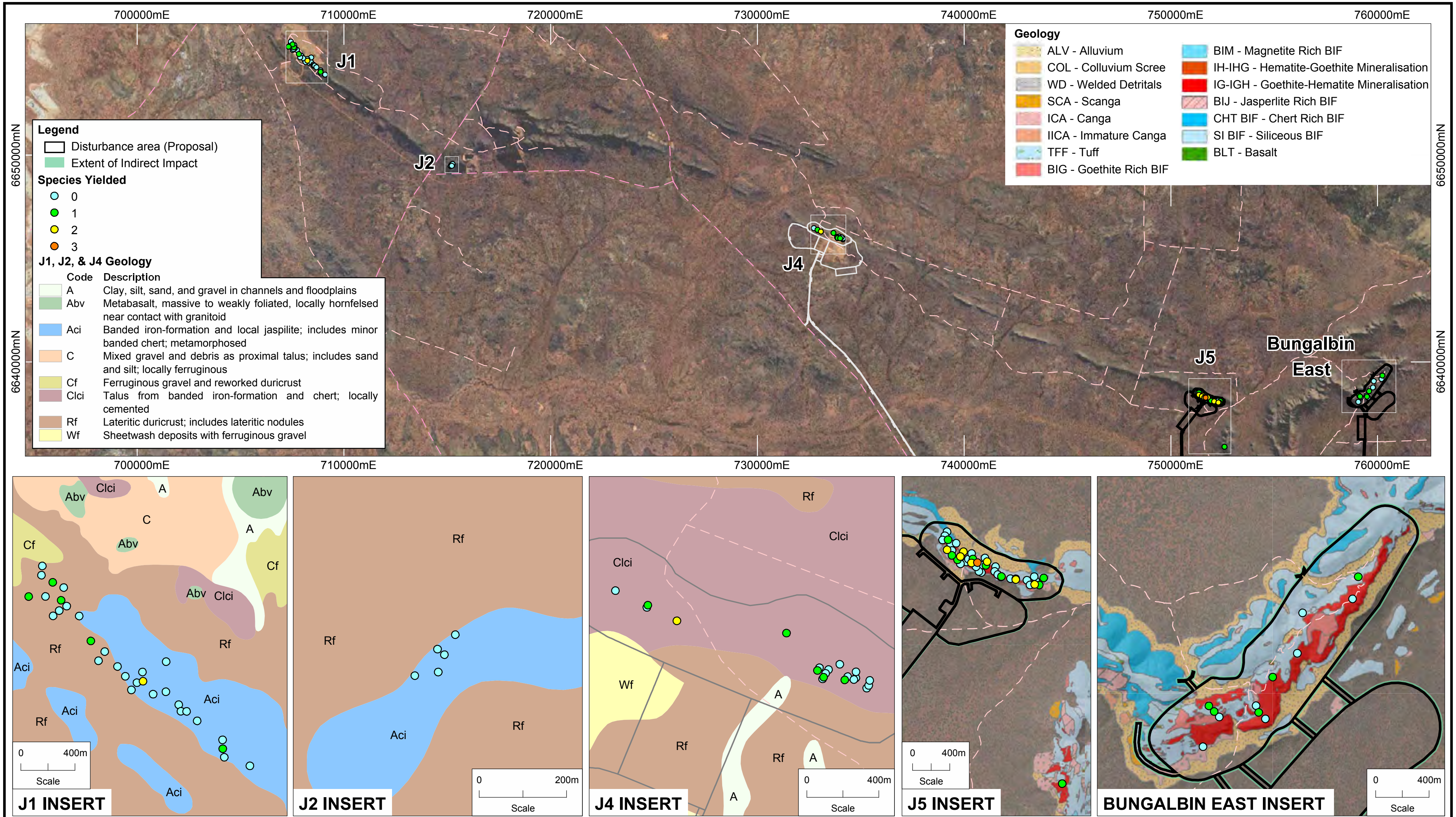
SAMPLING EFFORT FOR TROGLOFAUNA AT J5 AND BUNGALBIN EAST DEPOSIT

Figure: **7-2**



Source: Infrastructure supplied by Mineral Resources (July 2016)
Sample Sites supplied by Bennelongia Env. Cons. (July 2016)
Imagery: Landgate (2012), U.S. Geological Survey

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TROGLOFAUNA SAMPLE SITES ALONG THE JACKSON RANGE AND NUMBER OF SPECIES YIELDED FROM EACH SITE

Figure: **7-3**

TABLE 7-2: TROGLOFAUNA SAMPLING EFFORT

Location and Year	In-pit				Ex-pit		
	Scrape	S[1]-Trap	D[2]-Trap	Samples	Scrape	D-Trap	Samples
Bungalbin Central							
2015	-	-	-	-	1	1	1
TOTAL:	**-**	**-**	**-**	**-**	**1**	**1**	**1**
Bungalbin East							
2012	10	10	-	10	-	-	-
2013		-	10	5	-	-	-
2015	11	8	3	11	-	-	-
TOTAL	**21**	**18**	**13**	**26**	**-**	**-**	**-**
J5							
2007-08	32	23	9	32	-	-	-
2015	8	8	2	9	-	-	-
TOTAL	**40**	**31**	**11**	**41**	**-**	**-**	**-**

[1] S-Single Trap
[2] D-Double Trap

TABLE 7-3: TROGLOGAUNA SPECIES COLLECTED

Taxonomy	Bungalbin East	Bungalbin Central	J5 Deposit	Comments	Geological unit
	In-pit	Out-of-pit	In-pit		
Arachnida					
Araneae					
nr Gnaphosidae sp. B04	-	-	1	#, similar species at J1 deposit	Siliceous BIF
Prethopalpus sp. B31	-	-	1	Known only from this record	Siliceous BIF
Malacostraca					
Isopoda					
Philosciidae 'bungalbin'	1	-	-	Possibly conspecific with ?*Haloniscus* sp. B04	Siliceous BIF
?*Buddelundia* sp. B02	-	-	2	#, similar species at J4 deposit	Goethite mineralisation and Canga

Taxonomy	Bungalbin East	Bungalbin Central	J5 Deposit	Comments	Geological unit
	In-pit	Out-of-pit	In-pit		
?*Haloniscus* sp. B04	-	-	1	#, similar species at J1 deposit and Koolyanobbing Range	Siliceous BIF
Trichorhina sp. B28	3	-	18	#, similar species at J1, J4 deposits	Goethite mineralisation and Siliceous BIF
Chilopoda					
Geophilida					
Chilenophilidae sp. B01	-	-	1	Known only from this record	Canga
Scolopendrida					
Cryptops (*Trigonocryptop s*) sp. B03	-	-	1	#, known only from this record	Siliceous BIF
Pauropoda					
Tetramerocerata					
Pauropodidae sp. B08	-	-	1	#, known only from this record, diff. species from Pauropodidae sp. B36	Goethite mineralisation
Pauropodidae sp. B36	1	-	-	Known only from this record	Siliceous BIF
Symphyla					
Cephalostigmat a					
Hanseniella sp. B03	-	-	1	Similar species at J1, J4 deposits and Koolyanobbing Range	Goethite mineralisation
Hanseniella sp. B29	-	2	-	Known only from this record; similar surface species known from J5 deposit	Canga
Entognatha					
Diplura					
Diplura sp.	-	-	1	Known only from this record	Goethite mineralisation
Insecta					

Taxonomy	Bungalbin East	Bungalbin Central	J5 Deposit	Comments	Geological unit
	In-pit	Out-of-pit	In-pit		
Thysanura					
Hemitrinemura sp. B02	-	-	5	Known only from this record	Goethite mineralisation and Siliceous BIF
Coleoptera					
Myrtonymus sp. B05	-	-	7	#, known only from these records	Goethite mineralisation and Siliceous BIF
Myrtonymus sp. B06	1	-	-	Known only from this record	Goethite mineralisation

Survey Limitations and Constraints

As discussed in **Section 7.3**, it is likely that species occurring within the proposed mine pits have ranges extending outside the pits; however positive demonstration of this was hampered by two factors.

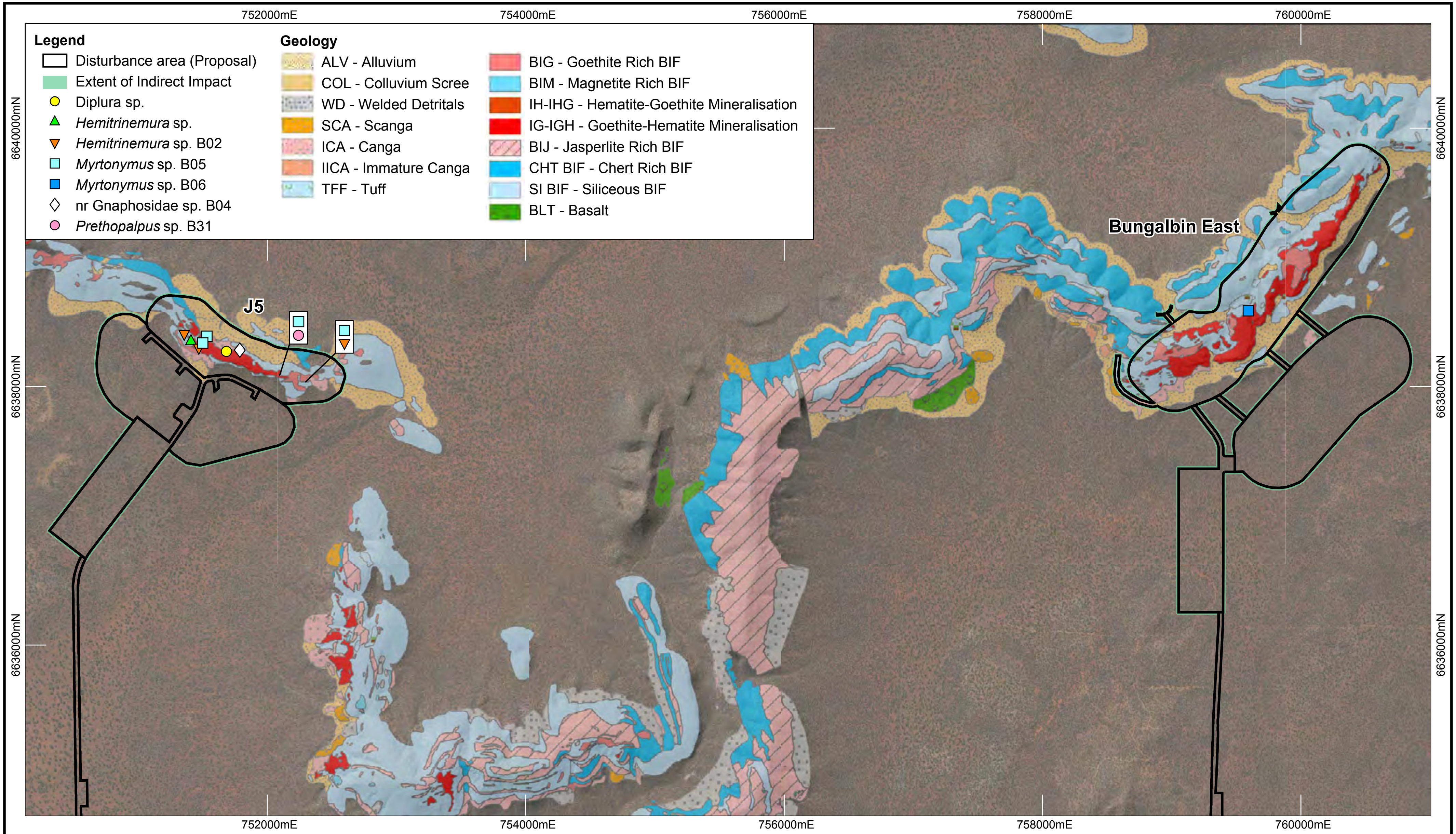
- Lack of drill holes outside the pits at Bungalbin East and J5 - DPaW does not support drilling in the HAR to enable broader troglofauna sampling or extend current geological habitat mapping because of the conservation values of this area and the management purpose of the conservation park. Therefore, MRL was not able to undertake any drilling to inform this PER and subterranean fauna sampling locations were limited to old exploration holes from BHP at Bungalbin East and Bungalbin Central and from Portman at J5 that remain open.
- Specimens of species collected in past surveys have been inaccessible because of building activity at the WAM, overseas loans or because these specimens have not been lodged with the WAM. Furthermore, many of the specimens from previous surveys are old or have been stored in such a way they are unsuitable for use in genetic analyses.

Species distribution and richness

The survey collected 12 species known from the J5 deposit and four species from the Bungalbin East deposit (**Figure 7-4** and **Figure 7-5**).

The degree to which the assemblages at the two deposits overlap is unclear – there are some shared species, e.g. the slater *Trichorhina* sp. B28 occurs at both deposits as possibly does the slater Philosciidae ‘bungalbin’/*?Haloniscus* sp. B04. Other groups such as weevils and pauropods appear to be represented by different species in each range (**Table 7-3**).

At least four of the species from J5 and Bungalbin East may have also been collected from other deposits in the Jackson Range or elsewhere (**Table 7-3**, **Figure 7-3**) but the identifications to support these wider ranging occurrences are uncertain as the specimens from the outlying areas were unavailable or too poorly preserved for comparison. The potentially wider ranging species include the spider nr Gnaphosidae sp, B04, the slaters *Buddelundia* sp. B02 and *Trichorhina* sp.B28 and the symphylan *Hanseniella* sp.B03.



Source: Infrastructure supplied by Mineral Resources (July 2016)
Fauna supplied by Bennelongia Env. Cons. (July 2016)
Imagery: Landgate (2012)

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CAD Ref: g2378_J5_BE_PER_C07_F04
Date: July 2016 | Rev: B | A4

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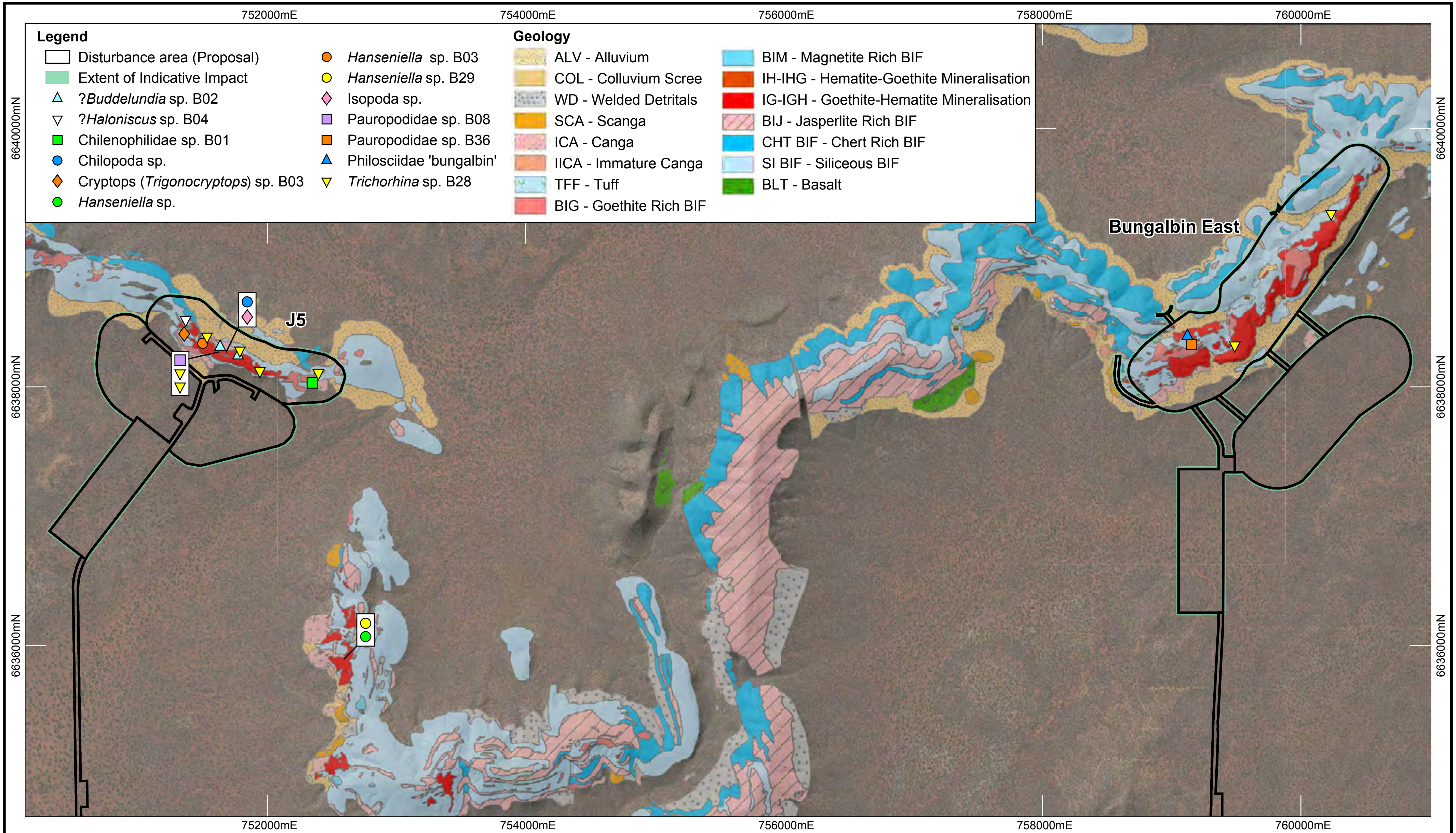
ARACHNID, INSECT AND DIPLURAN SPECIES COLLECTED

Figure: **7-4**



Source: Infrastructure supplied by Mineral Resources (July 2016)
Fauna supplied by Bennelongia Env. Cons. (July 2016)
Imagery: Landgate (2012)

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ISOPOD, PAUROPOD, SYMPHYLAN AND CENTIPEDE SPECIES COLLECTED FROM BUNGALBIN EAST AND J5

Figure: **7-5**

Nine troglofauna species are known only from Bungalbin East (two species) or J5 (seven species). These are the arachnid *Prethopalpus* sp. B31, the chilopods *Chilenophilidae* sp. B01 and *Cryptops (Trigonocryptops)* sp. B03, the pauropods Pauropodidae sp. B08 and Pauropodidae sp. B36, the bristle-tail Diplura sp. and the insects *Hemitrinemura* sp. B02, *Myrtonymus* sp. B05 and *Myrtonymus* sp. B06. Further discussion of species distributions is provided in **Section 7.3.1**.

Abundance and Sampling Efficiency

Use of EstimateS software and the ICE species richness estimator suggests at least 28 troglofauna species occur at J5, with the collecting efficiency to date being 35%. The ICE species richness estimator suggests at least 10 troglofauna species occur at Bungalbin East, with the collecting efficiency to date being 40%.

A moderate increase in sampling effort to the levels recommended in EPA Guidance Statement 54A is unlikely to do much more to characterise the troglofauna assemblage at each deposit because the two assemblages appear to be difficult to sample.

Most species occur in low abundance and it is possible that the network of vugs or fissures inhabited by troglofauna is sparse, so that a relatively high proportion of drill holes do not intersect troglofauna habitat even in areas considered to be prospective for troglofauna. While additional sampling should improve knowledge of the species composition of the troglofauna assemblages, it is likely that the number of species known from only one animal or a single hole may remain high.

Habitat

There is no diamond drill core available from Bungalbin East or J5 and drill logs provide little information about the suitability for troglofauna of the different geologies in the Proposal area and its surrounds. However, based on habitat analyses elsewhere, it is likely mineralised or weathered iron formations and associated hardcap in the Proposal area contain vugs, voids or fissures and other spaces that provide suitable habitat for troglofauna. Colluvium on scree slopes is also likely to provide habitat for some troglofauna species.

Geological mapping shows that drill holes yielding troglofauna at J5 were located in goethite mineralisation, mineralised canga or siliceous BIF, while holes yielding troglofauna at Bungalbin East were located in goethite mineralisation or siliceous BIF (**Figure 7-1**). The collection of troglofauna from siliceous BIF suggests that pockets of mineralised habitat occur within this formation in some areas.

The single drill hole sampled at Bungalbin Central (which also yielded troglofauna) was also located in goethite mineralisation. Overall, nine of the 16 troglofauna species in the Proposal disturbance area were found in siliceous BIF, three in canga and eight in goethite mineralisation (one was in both goethite mineralisation and canga and three in goethite mineralisation and BIF). No troglofauna were recorded in other mapped geological units although hematite mineralisation and, to a lesser extent, other weathered BIFs might also be expected to yield troglofauna.

Most (75 %) of the goethite mineralisation in the vicinity of the Proposal disturbance area lies within the proposed mine pits (**Table 7-4**). Although the proportion of canga within the Proposal area around J5 and Bungalbin East is high (91 and 55 %, respectively) this represents a relatively small proportion (30 %) of what is in the vicinity. Only 10 % of the siliceous BIF in the vicinity occurs within the proposed mine pits and this formation extends widely throughout the HAR. (Table 7-4)

It has been shown that most forms of BIF in the Yilgarn support troglofauna species when weathered, particularly in the vicinity of Koolyanobbing. The entire Mt Jackson and Helena-Aurora Ranges are considered prospective for troglofauna where rocks are mineralised, with troglofauna recorded from Jackson 1 and Jackson 4 (Figure 7-3, **Appendix 7-A**). In this context, the occurrence of a relatively high proportion of troglofauna in the Proposal disturbance area in siliceous BIF may not be unexpected. It suggests some weathering is present in the BIF.

The pattern of geology, especially the near continuous occurrence of siliceous BIF, suggests there is likely habitat connectivity beyond the proposed mine pits for troglofauna. Another reason to expect that species will have ranges extending beyond the proposed mine pits is the small size of these pits comparative to typical troglofauna ranges. This is discussed in detail in **Section 7.5**.

TABLE 7-4: TROGLOFAUNA HABITATS

Code	Geological Unit	J5		Bungalbin East		Total	
		Mapped Area (ha)	% Impact	Mapped Area (ha)	% Impact	Mapped area (ha)	% Impact
ALV	Alluvium	0.0	-	3.6	96.9	3.57	96.90
COL	Colluvium Scree	96.7	15.5	144.8	23.7	383.25	12.85
WD	Welded Detritals	0.0	-	74.0	-	100.21	0.00
SCA	Scanga	0.0	-	7.7	1.2	25.52	0.38
ICA	Canga	4.3	90.6	7.1	55.1	26.20	29.87
IICA	Immature Canga	0.0	-	4.1	0.7	4.13	0.73
TFF	Tuff	0.0	-	28.8	23.6	31.60	21.47
BIG	Goethite Rich BIF	7.1	35.7	8.4	89.6	19.84	50.52
BIM	Magnetite Rich BIF	0.0	-	0.07	-	1.57	0.00
IH-IHG	Hematite-Goethite Mineralisation	0.0	-	0.03	67.4	0.03	67.36
IG-IGH	Goethite-Hematite Mineralisation	8.3	83.2	30.6	97.8	49.16	74.92
BIJ	Jasperlite Rich BIF	0.9	-	197.0	0.2	250.15	0.18
CHT BIF	Chert Rich BIF	20.0	24.3	169.6	1.8	209.07	3.81
SI BIF	Siliceous BIF	101.2	13.5	197.9	27.3	697.66	9.69
BLT	Basalt	0.01	-	13.0	-	13.01	0.00
	Unmapped	-	-	5.6	-	-	-

7.3 Assessment of potential impacts

The potential impacts of the proposal on subterranean fauna are:

- loss of habitat for troglofauna as a result of mine pit excavation with the associated mortality of animals in these areas
- degradation of habitat for troglofauna arising from ground disturbance, stockpiling and potential surface contamination (hydrocarbons) and the associated mortality (which is considered likely to be minor).

7.3.1 Direct impacts

Direct impacts are considered here to be those associated with loss of habitat rather than degradation. Thus, mine pit excavation has a direct impact of the troglofauna present within the area of excavation.

In this assessment, the predicted extent of direct impacts on subterranean fauna has been assessed at regional and local scales with respect to the removal of fauna individuals and their habitat.

Stygofauna

The available evidence indicates that significant numbers of stygofauna are unlikely to occur at either J5 or Bungalbin East because the depth to groundwater is about 200 m at Bungalbin East and 130 m at J5. The groundwater abstraction proposed is limited to the small amount required for dust suppression around the mine, rather than dewatering. The majority of process water will be sourced from the existing water infrastructure at Carina and J4. Accordingly, stygofauna mortality and/or habitat loss arising from abstraction of groundwater is not expected to occur.

Troglofauna

The Proposal will directly impact some troglofauna individuals and from identified species as well as potential habitat. Eight species are currently known only from goethite mineralisation and 75 % of goethite mineralisation in the vicinity of the Proposal will be removed. However, given the occurrence of many species in siliceous BIF and canga (90 and 70 % retained, respectively), it is likely that some or most of these species will also occur in patches of weathered BIF. Other species may be found in the remaining goethite mineralisation.

J5

In addition to geology, there is at least some evidence based on survey to suggest that eight of the 12 troglofauna species known from the J5 deposit are more widespread:

- The isopod Trichorhina sp. B28 has also been collected at the Bungalbin East deposit and almost certainly occurs in areas between the two deposits.
- The slater ?Haloniscus sp. B04 has probably been recorded at Bungalbin East as Philosciidae ‘bungalbin’ and, if these are the same species, it would be expected to occur between the deposits.
- The silverfish Hemitrinemura sp. B02 is expected to be relatively widespread in the local area around J5 because related species in the Pilbara have a median range of 11 km^2 (Halse & Pearson, 2014) with many species of Trinemura and Hemitrinemura being substantially more widespread.
- The spider nr Gnaphosidae sp. B04, the slater ?*Buddelundia* sp. B02 and the symphylan *Hanseniella* sp. B03 may be more widespread in the the Mt Jackson Range than just J5 because similar specimens have been collected from the J1 and

J4 deposits in past troglofauna surveys. Unfortunately, these specimens are either unavailable for study or too poorly preserved to confirm the wider ranges.

- The two subterranean centipedes, Chilenophilidae sp. B01 and *Cryptops* (*Trigonocryptops*) sp. B03, belong to a group of species that are difficult to sample and occur at very low abundance but are likely to be moderately widespread because they commonly use tree roots and microfissures for dispersal.

With respect to the other four species collected at J5, it is reasonable to infer the species are more widespread. It is emphasised that there is inter-connected BIF geology along the Mt Jackson Range deposits that extends ca. 52 km in a north-westerly direction. There are no clear barriers to dispersal of troglofauna species that might lead to allopatric speciation, despite some minor fault lines and alluvial plains that bisect the deposits. Thus, species might be expected to have ranges encompassing larger fractions (and multiple deposits) of the Mt Jackson Range.

In this context, the proposed J5 pit covers only 61 ha (1.6 km x 0.35 km) and constitutes only 3 % of the total Mt Jackson Range (between the J5 deposit in the south-east and Mt Jackson to the north-west). No Western Australian troglofauna species has a published range smaller than this proposed mine pit and, given the inter-connected BIF geology of the Mt Jackson Range, it is most unlikely that any of the species collected here will be restricted to an area as small as the proposed mine pit. Thus, it is considered unlikely that the persistence of any troglofauna species will be threatened by mining at J5.

Bungalbin East

Three of the four troglofauna species known from the Bungalbin East deposit were collected as single animals, while one species (the slater *Trichorhina* sp. B28) is known to be more widespread. The three singleton species were the isopod Philosciidae ‘bungalbin’, which is considered likely to be the same species as *Haloniscus* sp. B04 from J5, the beetle *Myrtonymus* sp. B06 and Pauropodidae sp. B36. For the latter two species, geology is likely the best predictor of species distributions.

- Pauropodidae sp. B36 was recorded in siliceous BIF. While *Myrtonymus* sp. B06 was recorded in goethite mineralisation, it is likely to also utilise siliceous BIF in the same way as the related *Myrtonymus* sp. B05 from J5 does. Siliceous BIF is widespread in the HAR.

There is inter-connected BIF geology along the HAR that extends ca. 23 km in a south-easterly direction, with some additional outcropping to the north-west. There are no clear barriers to dispersal of troglofauna species in this range and it is considered likely that both the beetle and pauorpod have distributions that extend outside the mine pit. The median linear ranges of these troglofaunal groups in the Pilbara are >5 km for beetles and >3 km for pauropods.

The proposed pit area at Bungalbin East covers an area of 146.6 ha (2.6 km x 0.6 km) and constitutes 4.25 % of the Helena Aurora Range. It extends several km in a north-easterly direction, with additional outcropping and faulting to the south-west. Thus it is considered unlikely that any of the three singleton species at Bungalbin East will be threatened by mining at Bungalbin East.

7.3.2 Indirect impact

Some aspects of the Proposal have the potential to introduce environmental effects on troglofauna beyond those experienced directly as a result of mine pit development and associated removal of habitat.

The indirect impacts on troglofauna that may occur as a result of implementation of the Proposal include the effects of percussion from blasting, alteration of patterns of drainage and nutrient flow as a result of landform construction, drying of surrounding habitat and contamination of landforms.

Indirect impacts are expected to dissipate rapidly beyond the mine pits, and are more likely to cause reductions in populations of troglofauna, if at all, than they are to threaten the persistence of species (**Appendix 7-A**).

7.4 Proposed environmental management

No specific management of subterranean fauna is proposed because: (a) there are no stygofauna species likely to occur within the disturbance area; and (b) the volume of troglofauna habitat that will be lost relative to the potential troglofauna habitat available beyond the disturbance area is small.

7.5 Residual impacts

No mitigation is proposed to otherwise reduce the impact of the Proposal on subterranean fauna. The residual impact therefore comprises the removal of all troglofauna individuals and their habitat within the pit areas.

Having reviewed all previous troglofauna sampling of the HAR and neighbouring BIF ranges, as well undertaking further sampling, Bennelongia Environmental Consultants concluded that:

- the mine pit areas are small compared to the known ranges of highly restricted troglofauna species elsewhere in Western Australia
- while goethite mineralisation has a restricted distribution, siliceous BIF geology extends more or less continuously for many kilometres and, if weathered, provides troglofauna habitat without any obvious barriers to dispersal that could restrict species ranges
- records of troglofauna species have been recorded elsewhere along the range (J1, J4), with some of these species being morphologically similar and perhaps the same species as recorded at J5 (**Appendix 7-A**).

At J5 potential additional troglofauna habitat is present to the north-west along the Jackson Range. At Bungalbin East potential additional troglofauna habitat is extensive to the south-west along the HAR. Thus, it is considered that the Proposal is unlikely to have a significant impact on troglofauna conservation values.

7.6 Predicted outcome

The EPA objective for subterranean fauna is:

- To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.

Troglofauna occur in low abundance within the HAR and are difficult to sample, with 75% of recorded species known only from one or two specimens and from single bores. While some additional sampling is required to meet the recommendations for sampling effort as stated in EPA Guidance Statement 54a, Bennelongia Environmental Consultants concluded that the extra sampling is unlikely to provide much more certainty about the ranges of troglofauna species occurring at J5 and Bungalbin East (**Appendix 7-A**).

It appears likely that the number of singletons i.e. species known only from one animal or a single hole may remain high even with additional sampling.

Irrespective of the limited sampling evidence of species occurrence beyond the disturbance area, the size of pits at J5 and Bungalbin East, combined with the known occurrence of a relatively high proportion of the fauna in siliceous BIF, which is a widespread geological unit, suggests that species recorded to date are likely to occur outside the proposed mine pits.

At J5 additional troglofauna habitat potentially occurs to the north-west along the Jackson Range. At Bungalbin East, additional troglofauna habitat potentially extends south-west along the HAR.

Accordingly, the Proposal can be implemented whilst meeting the EPA's objective to maintain the representation, diversity, viability and ecological function of troglofauna at the species, population and assemblage levels.

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8. TERRESTRIAL FAUNA

8.1 EPA objective, policies and guidance

The EPA objective for terrestrial fauna is:

- to maintain representation, diversity, viability and ecological function at the species, population and assemblage level.

The policy and guidance documents referenced as part of the field investigations and impact assessment are provided in **Table 8-1**.

TABLE 8-1: LEGISLATION, POLICIES AND GUIDANCE CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
EPA (2002). Position Statement 3: Terrestrial biological surveys as an element of biodiversity protection. Perth, Western Australia.	Outlines the overarching principles for environmental impact assessment of biodiversity, including survey requirements, demonstration that all reasonable measures to avoid impacts have been taken, demonstration of no unacceptable loss and the application of genetic studies in impact assessment. The EPA expects that all terrestrial biological surveys will be made publicly available.	The quality of information and scope of field surveys meets the standards, requirements and protocols as determined and published by the EPA and DPaW (Refer **Appendix 8-A**, **Section 1.2** and **Appendix 8-B**, **Section 3**). The PER demonstrates that all reasonable measures have been undertaken to avoid impacts on biodiversity and that the Proposal will not result in an unacceptable loss of biodiversity in respect of terrestrial fauna.
EPA (2004) Guidance Statement No. 56: Terrestrial fauna surveys for environmental impact assessment in Western Australia. Perth, Western Australia.	Addresses the general standards and a common framework for terrestrial fauna and fauna assemblages for EIA in WA. It also details expectations regarding the quality and quantity of survey information and analysis, interpretation and reporting.	The Guideline is referenced in the development of survey methods for terrestrial vertebrate fauna (Refer to **Section 3** in **Appendix 8-A** together with **Table 3-1** that addresses influencing factors). The survey report is consistent with expectations regarding quality and quantity of survey information as well as analysis, interpretation and reporting.

Legislation, Policy and Guidelines	Key Aspects	Application
EPA (2009). Guidance Statement No. 20: Sampling of short-range endemic invertebrate fauna for environmental impact assessment in Western Australia. Perth, Western Australia.	Addresses the general standards and a common framework for sampling and assessment of SRE invertebrate fauna for EIA in WA. It also details the EPA's expectations regarding quality and quantity of survey information and analysis, interpretation and reporting.	This Guideline is referenced in the development of survey methods (Refer to **Section 2.3.3** in **Appendix 8-B**) as well as the interpretation of survey results (**Section 5.2** in **Appendix 8-B** and **Section 8.3** of the PER).
EPA and DEC (2010). Technical guide – terrestrial vertebrate fauna surveys for environmental impact assessment. Technical report of the Environmental Protection Authority and the Department of Environment and Conservation.	Provides greater detail on regulator expectations for undertaking Level 1 and Level 2 surveys (as outlined in Guidance Statement 56), fauna survey protocols, methodology, analysis and reporting.	This Guideline is referenced in the development of survey methods (Refer to **Section 1.2** in **Appendix 8-A**) and has been applied in respect of data analysis and reporting.
EPA (2007). Report 1256: Advice on areas of the highest conservation value in the proposed extensions to Mount Manning Nature Reserve. Advice of the EPA to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986. Western Australia.	The advice primarily concerns Mt Manning Range Nature Reserve and proposed extensions, also known as the Yilgarn Conservation Reserves. This advice identifies areas that should be protected from mining and the use of environmental offsets. The advice makes numerous reserve recommendations including that part of the MMHARCP be reserved as an A Class Nature Reserve. The key factors listed in the advice include "important habitat for specially protected fauna" and "excellent representation of woodland, sandplain and other inadequately reserved vegetation and animal habitats."	The PER assesses the impact of the Proposal on vertebrate and SRE fauna (this section) described in Report 1256. Report 1256 does not provide specific guidance on the assessment of impacts to fauna.

Legislation, Policy and Guidelines	Key Aspects	Application
EPA Checklist for Documents Submitted for EIA on Marine and Terrestrial Biodiversity.	Provides the basis for consultants and proponents to conduct initial in-house screening of the quality of their EIA documents. It defines the minimum standard for the fundamental elements of EIA documentation to be submitted to the EPA.	All relevant items completed in relation to terrestrial fauna and provided to OEPA.
Commonwealth Policy and Guidelines		
Department for Environment and Heritage (2007). National recovery plan for Malleefowl (*Leipoa ocellata*). Adelaide, South Australia.	Outlines national objectives and actions required to improve the conservation status of Malleefowl. Includes survey guidelines.	Used to develop survey methods (**Appendix 8-A**, **Section 3.6.2**), summarised in PER **Section 8.2.1**.
DoE (2010). Survey Guidelines for Australia's Threatened Birds.	Provides proponents and assessors with guidelines to help determine the likelihood of a species' presence or absence at a site.	The PER is informed by a terrestrial vertebrate fauna assessment that includes bird surveys (point surveys).

This PER has been prepared to be consistent with all policy and guidance documents referenced in **Table 8-1**.

8.2 Existing environment

8.2.1 Vertebrate fauna

A terrestrial vertebrate fauna assessment of the Jackson and Helena-Aurora Ranges was undertaken by qualified zoologists from ecologia Environment during 2012-2013. A copy of the assessment is provided in **Appendix 8-A**.

The field survey program underpinning the assessment was designed in consultation with DPaW, who provided advice on appropriate survey methods for vertebrate and short-range endemic fauna surveys in the Yilgarn. The final program comprised a multi-season, Level 2 field trapping survey conducted over spring/summer 2012, autumn 2013 and spring 2013.

As outlined in **Appendix 8-A**, all terrestrial vertebrate fauna surveys and methods were consistent with EPA Position Statement No. 3 (2002); EPA Guidance Statement No. 56 (2004); and EPA and EPA/ DEC (2010).

The surveys underpinning the assessment were undertaken from 13-25 December 2012 (Phase 1), 3-11 April 2013 (Phase 1 remaining sites and Phase 2) and 9-17 October 2013 (Phase 2 remaining sites).

Briefly, the vertebrate fauna survey methods used to document assemblages included systematic trapping (pitfall, funnel, Elliot box and Sheffield cage traps), systematic bird censuses, systematic diurnal site searches, targeted searches of microhabitats, spotlighting, camera trapping, SM2BAT bat echolocation recording and opportunistic detection. For species of conservation significance, targeted searches were undertaken in appropriate habitats.

In addition, the methods utilised to establish whether Malleefowl occur within the study area were consistent with DoE (2010), which recommends searching suitable habitat for active mounds, tracks and sightings as the best method of detection. Mounds were assessed in accordance with the guidelines published by the Malleefowl Preservation Group.

The study area covered the entire Helena-Aurora Range (HAR) and the eastern extent of the Jackson Range (**Figure 8-1**). Twelve vertebrate fauna systematic survey sites were established within the study area, chosen to achieve a geographic spread over the area within representative habitat types (**Figure 8-2**). Habitat types that were potentially under-represented by survey sites were further surveyed using opportunistic searches that targeted potentially sensitive habitat as well as habitat likely to support conservation significant fauna species (e.g. Malleefowl – refer **Figure 8-3**).

The overall survey effort across both phases of the survey and all habitat types is summarised in **Table 8-2**. Desktop analyses to supplement the field surveys included database searches and reviews of other reports on vertebrate fauna surveys conducted across the region, both within and beyond the study area.

TABLE 8-2: TOTAL SURVEY EFFORT FOR VERTEBRATE FAUNA

Survey method								
Traps (trap nights)					Opportunistic (min)		Birds (min)	Bat (hrs)
Pits	Funnel	Elliott	Cage	Camera (hrs)	Diurnal	Nocturnal		
1,740	3,460	1,740	346	10,896	5,675	1,390	3,370	516

Fauna habitat

There are six major vertebrate fauna habitat types within the study area (**Figure 8-2**). The most extensive fauna habitat types are 'mixed eucalypt woodland' (63 %) followed by 'mallee woodland on rocky plain and footslopes' (23 %) and 'sandy plain with shrubland' (11 %). The remaining three habitat types – 'rocky ridge', 'drainage line' and 'seasonal swamp' – together occupy less than 4 % of the study area.

The rocky ridge and mallee woodland on rocky plain and footslopes habitat types are approximately coincident with the "Helena and Aurora Ranges Vegetation Complexes" Priority Ecological Community (PEC) as described in **Appendix 8-A**.

Fauna assemblage

A total of 17 native and three introduced species of mammals, 87 species of bird, 48 species of reptile and two species of amphibians were recorded from the study area (**Appendix 8-A**):

- The 17 native mammal species are comparable to previous fauna surveys conducted in the region, and include four species of small, carnivorous marsupials, two species of mice, a pygmy possum species and nine bat species. The introduced mammal species were the Feral Cat, House Mouse and European Rabbit, the latter two of which were the most often recorded mammal species.
- No mammals of conservation significance were recorded during the survey. The results of the desktop study and field survey indicate a medium likelihood that one mammal species of conservation significance, the Chuditch (Western Quoll), may occur in the study area (see next section).

- The number of bird species recorded (87) during the survey is typical of the region, with the most abundant species being the Weebill, Yellow-plumed Honeyeater, Striated Pardalote, Spiny-cheeked Honeyeater, White-fronted Honeyeater, Brown Honeyeater and Grey Strike-Thrush. The most abundant bird family recorded was the Honeyeaters with 12 species from 889 records within the study area. The family Artamidae was also commonly recorded with 8 species from 176 records.
- Four bird species of conservation significance were recorded from the study area (Malleefowl, Fork-tailed Swift, Rainbow Bee-eater and Peregrine Falcon). The results of the desktop study and field survey indicate that there are no other species of conservation-significant avifauna with a significant probability of occurring in the study area (i.e. a likelihood of occurrence of ‘medium’ or higher) (**Appendix 8-A**).
- A total of 46 reptile species and two amphibian species were recorded within the study area. The reptile assemblage comprised six dragons, nine geckos, five legless lizards, 16 skinks, three goannas, one blind snake and eight front-fanged venomous snakes. The amphibian species recorded comprised four individuals of the Western Toadlet and the Humming Frog.
- No reptiles or amphibians of conservation significance were recorded during the survey, and the desktop study did not identify any amphibians of conservation significance as potentially occurring in the study area. The results of the desktop study and field survey suggest a medium likelihood that one reptile species of conservation significance, the Woma, may occur in the study area.

Conservation significant vertebrate fauna species

Database searches and previous biological surveys within 35 km of the study area suggested that 40 vertebrate fauna species of conservation significance could occur within the study area, comprised of seven mammal, 31 bird and two reptile species (**Appendix 8-A**).

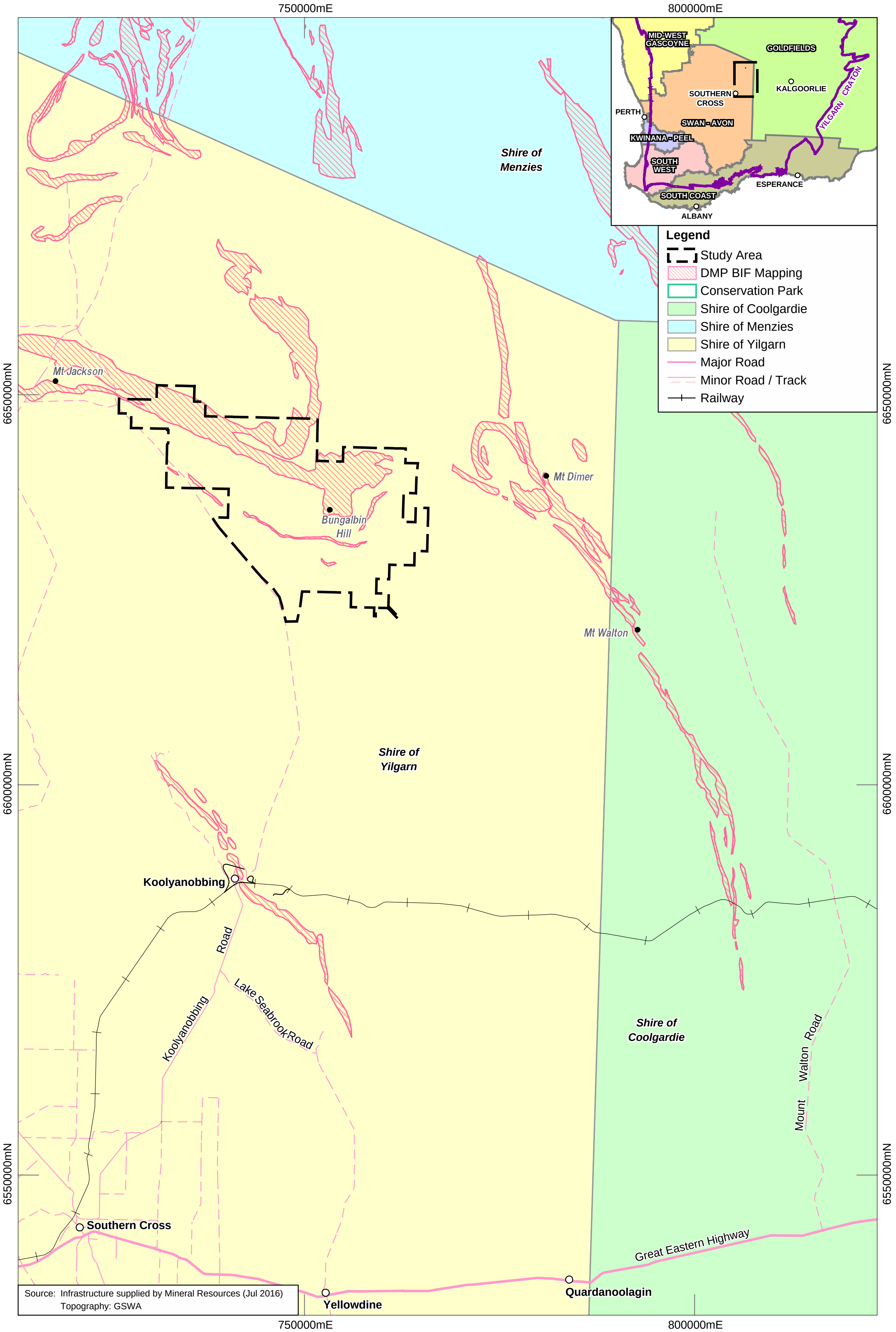
At the time, further investigation by ecologia Environment (**Appendix 8-A**) identified that 11 of these 40 species have a medium to high likelihood of occurrence, or have been actually recorded, within the study area. The remaining 29 species were assessed as having a low likelihood of occurrence in the study area and are not considered further in this PER.

The database searches, literature review and field surveys were completed in 2012-2013. Since that time, a number of revisions to fauna listings under the Wildlife Conservation Act 1950 (WA) and DPaW Priority Fauna List have been made. This PER follows the most current listings, i.e. those published in the Wildlife Conservation (Specially Protected Fauna) Notice 2015 in the WA Government Gazette, 3 November 2015, and in the Threatened and Priority Fauna List on the DPaW website, 19 November 2015.

Consequently, the 11 species discussed in the baseline survey investigations as being of conservation significance and having a medium to high likelihood of occurrence in the study area are considered under different listing categories in this PER or, in some cases, are not considered further due to their having been de-listed (**Table 8-3**). All subsequent references in this PER to species of conservation significance are made in the context of the new listings.

Four of the six vertebrate fauna species of conservation significance with a medium or higher likelihood of occurrence in the study area were recorded by ecologia Environment (**Appendix 8-A**), all of which were birds:

- Malleefowl (Vulnerable, Schedule 3)
- Peregrine Falcon (Schedule 7)
- Rainbow Bee-eater (Migratory; Schedule 5)
- Fork-tailed Swift (Migratory, Schedule 5)



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0 5 10km

Scale 1:650,000
MGA94 (Zone 50)

CAD Ref: g2313_J5_BE_PER_C08_F09_01

Date: Jul 2016 | Rev: B | A4

Author: Mineral Resources

Drawn: CAD Resources ~ www.cadresources.com.au
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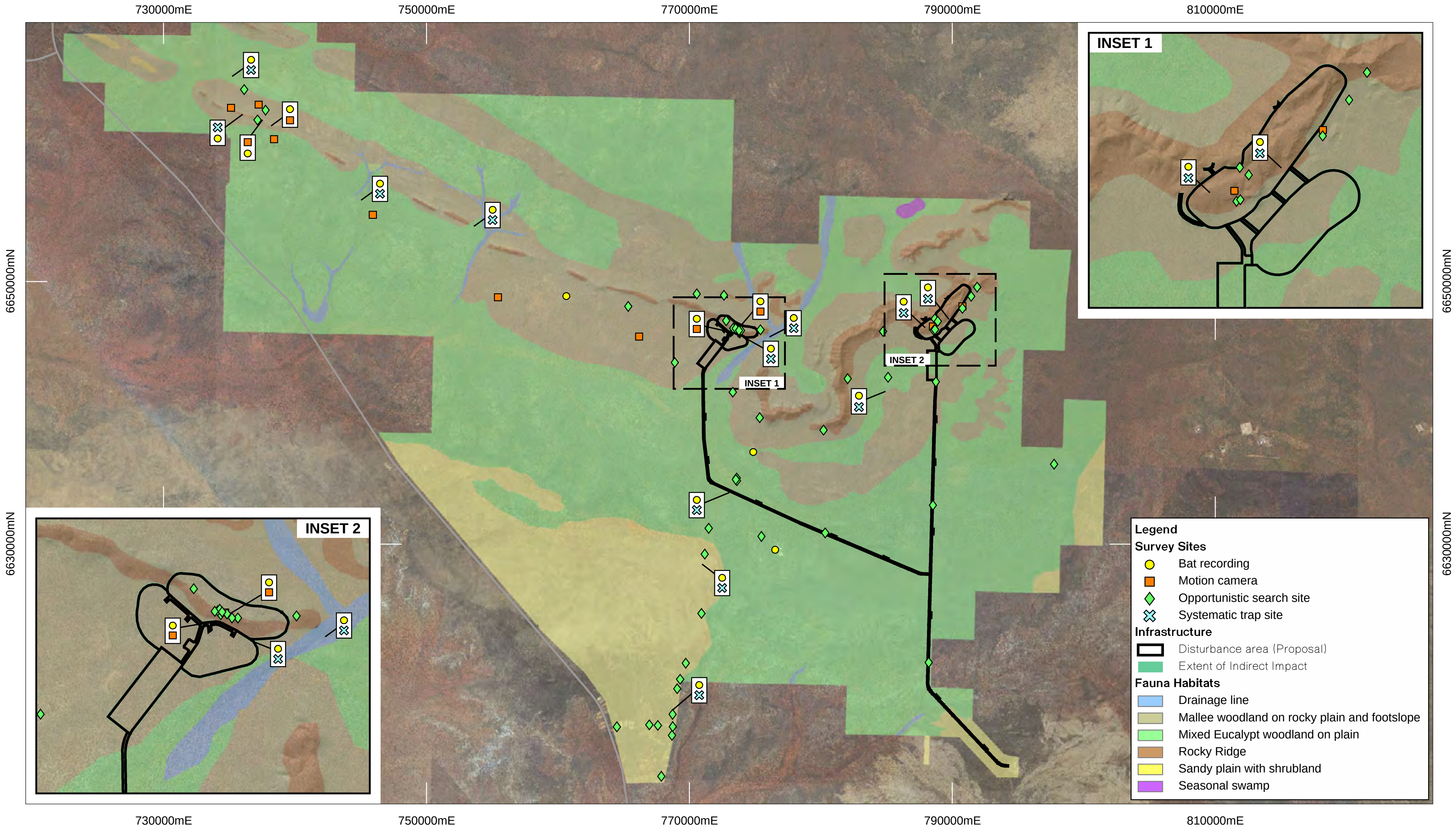
TERRESTRIAL VERTEBRATE FAUNA STUDY AREA

Figure:

8-1



Notes
Infrastructure supplied by Mineral Resources (July 2016)
Fauna habitats and sites supplied by Ecologia Environment (July 2016)

N

0 2 4km
Scale 1:200,000
MGA94 (Zone 50)
CAD Ref: g2378_J5_BE_PER_C08_F09_04
Date: July 2016 | Rev: A | A4

Author: Mineral Resources
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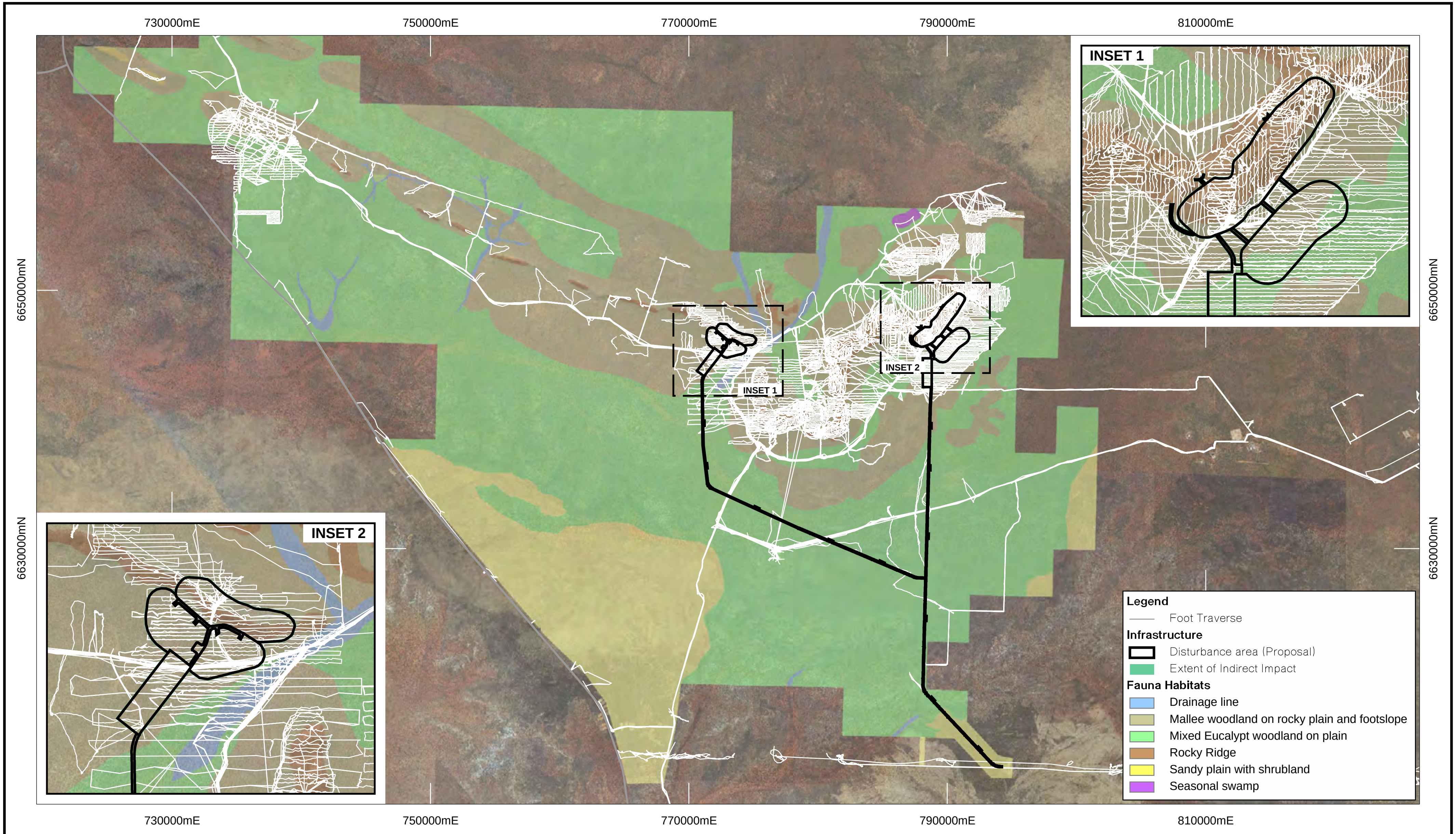
VERTEBRATE FAUNA HABITAT AND SURVEY SITES

Figure:
8-2



Note
Fauna habitats and transects supplied by Ecologia Environment (July 2016)

0 2 4km Scale 1:200,000 MGA94 (Zone 50)		
CAD Ref: g2378_J5_BE_PER_C08_F09_05		
Date: July 2016	Rev: A	A4

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MALLEEFOWL TRANSECTS AND FAUNA HABITAT

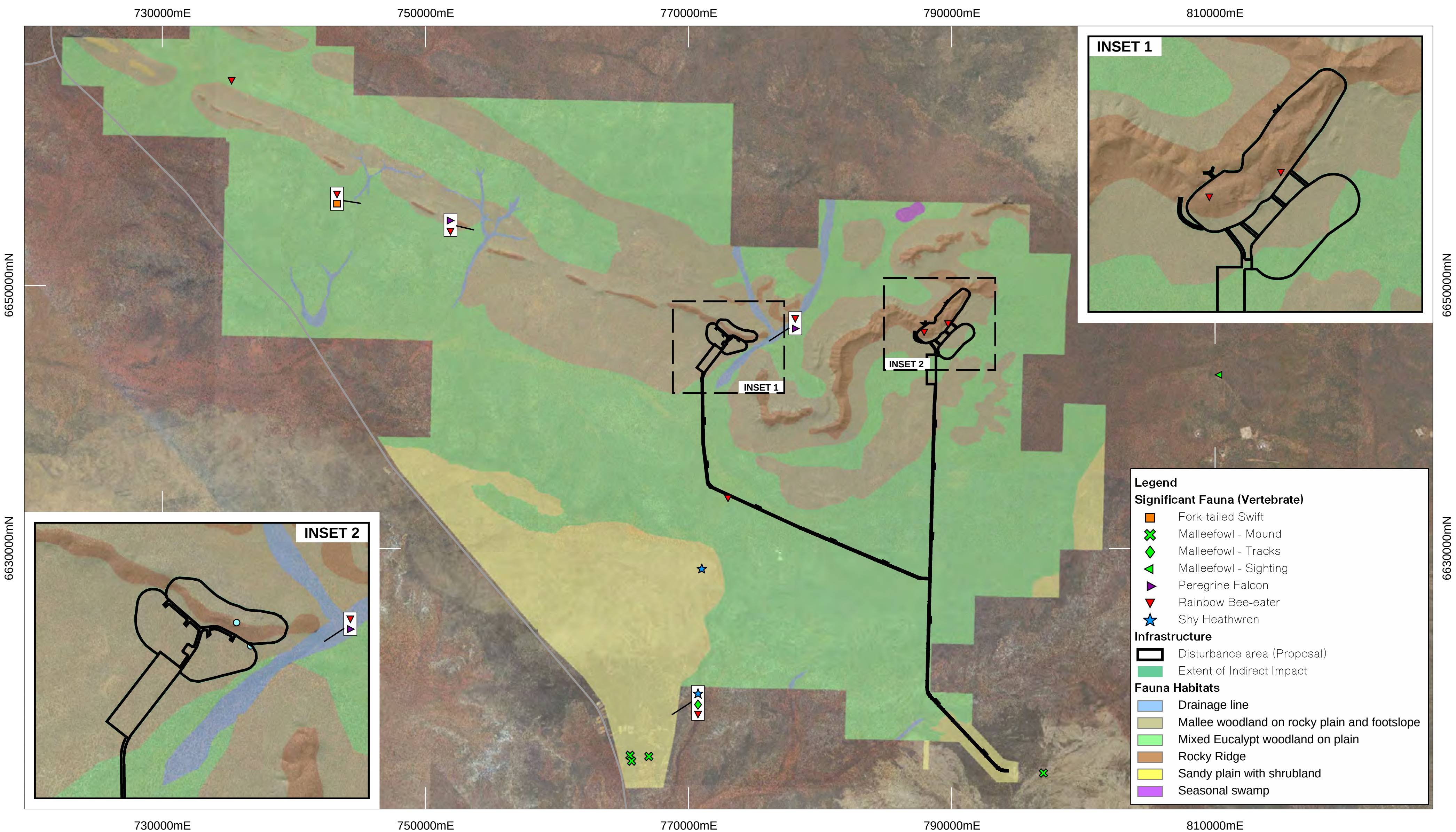
Figure:
8-3

TABLE 8-3: LISTING CHANGES FOR SPECIES OF CONSERVATION SIGNIFICANCE

Species ^	Previous status (Appendix 8-A)		Current status (this PER)	
	WC Act	DPaW	WC Act	DPaW
Chuditch (Western Quoll) *Dasyurus geoffroii*	Schedule 1 (VU)		Schedule 3 (VU)	
Malleefowl *Leipoa ocellata*	Schedule 1 (VU)		Schedule 3 (VU)	
Fork-tailed Swift *Apus pacificus*	Schedule 3		Schedule 5 (Migratory)	
Rainbow Bee-eater *Merops ornatus*	Schedule 3		Schedule 5 (Migratory)	
Peregrine Falcon *Falco peregrinus*	Schedule 4 (Other)		Schedule 7 (Other)	
Major Mitchell's Cockatoo *Lophochroa leadbeateri*	Schedule 4 (Other)		No longer listed Not considered further in PER	
Australian Bustard *Ardeotis australis*		Priority 4	No longer listed Not considered further in PER	
Shy Heathwren (Western) *Hylacola cauta whitlocki*		Priority 4	No longer listed Not considered further in PER[+]	
Crested Bellbird (Southern) *Oreoica gutturalis gutturalis*		Priority 4	No longer listed Not considered further in PER	
Woma *Aspidites ramsayi*	Schedule 4 (Other)	Priority 1		Priority 1
South-west Carpet Python *Morelia spilota imbricata*	(Other)	Priority 4	No longer listed Not considered further in PER	

^ species identified as being of conservation significance in the desktop study, literature review and field survey, and as having a medium or higher likelihood of occurrence in the study area.
[+] not considered in a conservation significant fauna context, although briefly discussed due to its dependence on BIF habitats – see next section.

The two other vertebrate fauna species of conservation significance that were not recorded by ecologia Environment (**Appendix 8-A**) during field surveys were the Chuditch (Western Quoll) and Woma. Although suitable habitat for these species is broadly present in the study area in the form of mixed eucalypt woodland, there are only a few previous records of each species within 100 km of the study area. Refer to **Figure 8-4** for the locations of vertebrate fauna recorded in the study area.



Note
Infrastructure supplied by Mineral Resources (July 2016)
Fauna data supplied by Pacific Environment Limited (Jan 2016)
Fauna habitats supplied by Ecologia Environment (July 2016)

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CAD Ref: g2378_J5_BE_PER_C08_F09_02

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LOCATIONS OF VERTEBRATE FAUNA AND HABITAT

Figure:
8-4

Vertebrate fauna significantly dependent on BIF habitat

In addition to the conservation significant species noted above, the then DEC (2007) previously identified several species considered to be at least partially dependent on BIF ranges for habitat. In particular, the HAR was identified as providing habitat for:

- Little Woodswallow (*Artamus minor*)
- Western Yellow Robin (*Eopsaltria griseogulgaris*)
- Woolley's Pseudantechinus (*Psuedantechinus woolleyae*)
- Shy Heathwren (*Hylacola cauta whitlockii*)
- Slender Blue-tongue (*Cyclodomorphus melanops*)
- Long-tailed Dunnart (*Sminthopsis longicaudata*)
- Gilled Slender Blue-tongue (*Cyclodomorphus branchialis*).

It was noted by DEC (2007) at the time that the fauna dataset for BIF ranges contained many limitations, particularly as fauna surveys had typically focussed on areas to be mined rather than the full extent of the ranges beyond those areas. With further survey of many ranges having been undertaken since 2007, clarification is provided below with regard to the Shy Heathwren, the Long-tailed Dunnart and the Gilled Slender Blue-tongue.

The Shy Heathwren (western subspecies) is not likely to be significantly dependent on BIF ranges for habitat based on the following information:

- The Shy Heathwren typically lives in shrubland and mallee woodland with a dense understorey where it forages on the ground for insects and seeds (Garnett & Crowley, 2000; Johnstone & Storr, 1998).
- It is found within WA's Wheatbelt region and as far east as Cocklebiddy (Saunders and Ingram, 1995 cited by ecologia Environment in **Appendix 8-A**), areas that are not known for BIF range habitat.
- It was recorded by ecologia Environment (**Appendix 8-A**) from the sandy plain and shrubland habitat south of the HAR, which typically offers a denser understorey than either the mallee and eucalypt woodland habitat found nearer to the BIF ranges.
- Ecologia Environment (**Appendix 8-A**) noted the occurrence of this species in the study area as being at the northern boundary of its typical distribution, whereas there are many BIF ranges in the Mt Manning area and further north in the Midwest region.

The Long-tailed Dunnart and the Gilled Slender Blue-tongue are not known from the HAR, based on the following information:

- The recorded occurrence of the Long-tailed Dunnart in the HAR is attributed to Lyons and Chapman (1997). It has not been recorded since and was not identified from the desktop study as potentially occurring in the area (**Appendix 8-A**).
- The southern extent of the known distribution of the Long-tailed Dunnart appears to be the Mid-West region.
- The recorded occurrence of the Gilled Slender Blue-tongue in the HAR is attributed to Lyons and Chapman (1997); however, it has not been recorded since from the HAR and more recent publications indicate that its known distribution is limited to the Mid-West region (Cogger, 2014; Wilson & Swan, 2010).
- It should also be noted that the Slender Blue-tongue (*Cyclodomorphus melanops*), which is more commonly found across WA and the Yilgarn, used to be called C. *branchialis* prior to taxonomic revision when C. *melanops* was identified. For this

reason, there are numerous instances where database records incorrectly identify the occurrence of C. *branchialis* (ecologia Environment. pers.comm).

8.2.2 Invertebrate fauna

A short-range endemic (SRE) invertebrate fauna assessment of the HAR was undertaken by Bennelongia Environmental Consultants. A copy of the assessment is provided in **Appendix 8-B**.

The field survey program underpinning the assessment included surveys by ecologia Environment during October-December 2012 (**Appendix 8-A**) and Bennelongia Environmental Consultants during November 2015 (**Appendix 8-B**). The survey approach and methods used were based on EPA Position Statement 3 (EPA, 2002) and EPA Guidance Statement 20 (2009).

In addition, the 2015 survey was designed in response to comments from the OEPA and DPaW regarding the need for improved regional context and for the study area to be delineated based on ecological characteristics.

In 2012, survey site locations were selected based on the vegetation associations, areas of impact and habitat types present in the study areas, focusing on the habitat types that were considered likely to support SRE invertebrates (south facing rocky hillslopes, drainage line, eucalypt woodland and sandy shrubland).

A total of 12 SRE wet pitfall sites (comprising five wet pitfalls each) were established and 53 foraging sites were searched for potential SRE species in addition to the wet pitfall trap sites. Leaf litter was taken from near the 12 wet pitfall sites as well as from 16 of the 53 opportunistic sites, to increase the likelihood of detecting terrestrial SRE species.

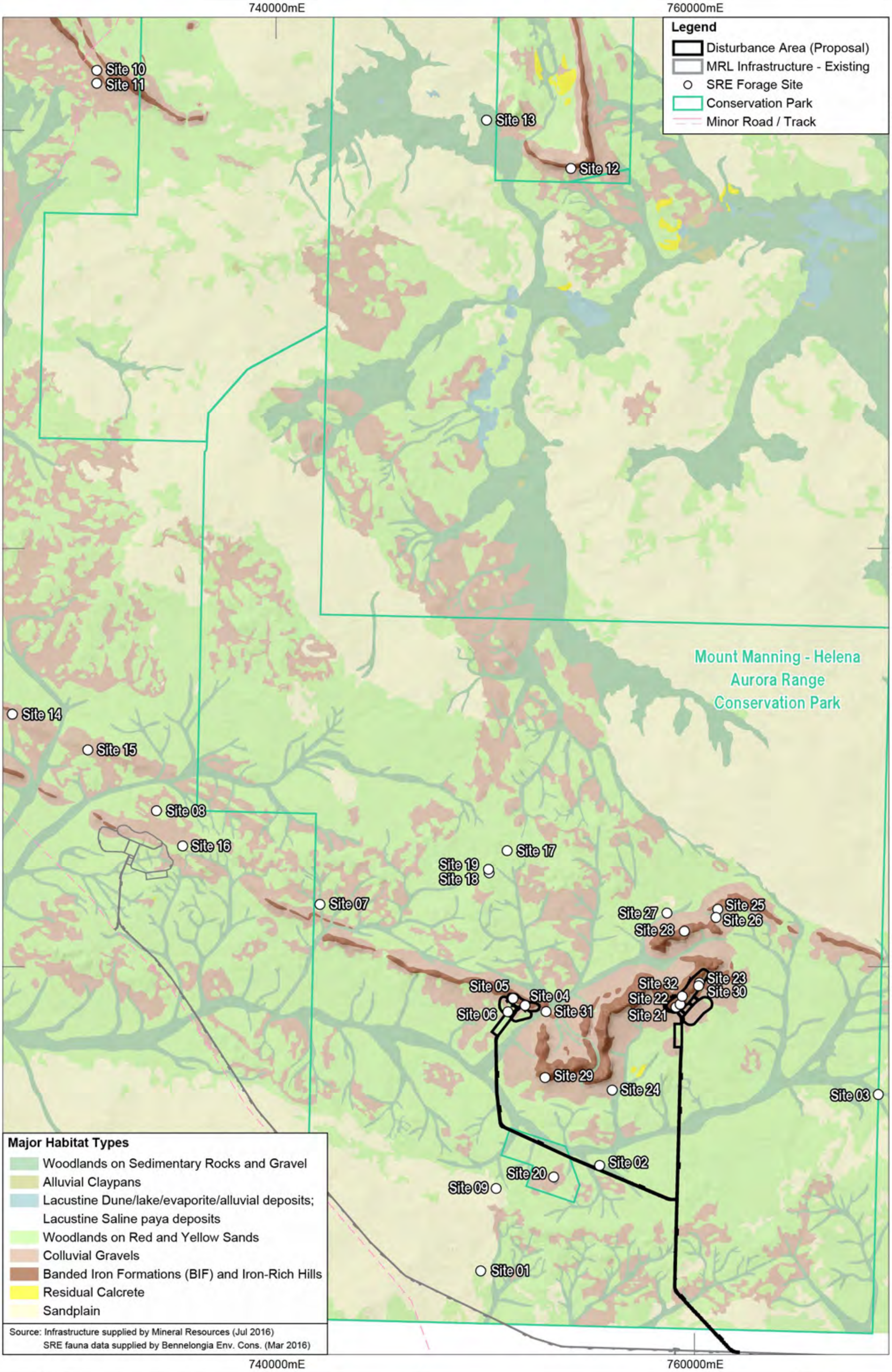
In 2015, the survey covered an extensive area including all major SRE fauna habitat types occurring in proximity to the Proposal. A total of 32 sites were sampled, including eight sites within the area to be disturbed by the Proposal, two nearby sites outside the disturbance area, 16 sites in the MMHARCP outside the development envelope four sites at Mt Jackson and two sites at Mt Geraldine (two sites, **Figure 8-5**).

Hand foraging was the primary method used to survey the study area although some cup traps were set as well. Much of the time was spent searching for burrows of mygalomorph spiders, which were excavated from their burrows and preserved at site.

At 24 sites a leaf blower was used to clear litter and facilitate the search for burrows. Scorpions were collected at night at six sites using ultraviolet (“black”) light torches. At four sites where scorpions were abundant, cup traps were fixed to the entrance of burrows and checked every morning. Leaf litter samples were taken at 24 sites and deep soil excavations at the base of *Eucalyptus* trees were undertaken at 19 sites.

Small species, such as pseudoscorpions, were extracted from dry and wet leaf litter using a soil sieve (16 sites), or were found by turning over tree logs (10 sites). *Acacia* and dry *Eucalyptus* tree bark was peeled at 13 sites to collect habitat specialists such as chernetid pseudoscorpions. Centipedes and slaters were collected by excavating deeper soil layers and bark detritus at the base of *Eucalyptus* trees.

Rock specialists such as *Synsphyronus* pseudoscorpions were collected from under rocks at breakaways, BIF habitats and accumulations of scree. Sampling occurred in all prospective microhabitats at each site, such as moist and dry leaf litter accumulations, around tree logs, under tree bark and in spinifex clumps.



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CAD Ref: g2313_J5_BE_PER_C08_F09_03

Date: Jul 2016 | Rev: C | A4

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SRE HABITAT TYPES

Figure: 8-5

Survey Limitations and Constraints

EPA Guidance Statement 20 recommends sampling to be undertaken in winter (May to August) when otherwise cryptic groups such as land snails are active and there is enhanced activity of male mygalomorph spiders. Both fauna surveys were carried out in spring (October-December 2012, November 2015) when conditions are drier and warmer.

Despite conditions being drier and warmer at the time the surveys were undertaken, the area received 43 mm of rainfall during the month of October 2015. This volume of rainfall is 27.4 mm higher than the long-term average and both surveys recorded diverse assemblages of SRE invertebrates that include cryptic groups such as *Bothriembron* land snails and *Antichiropus* millipedes and such groups were clearly active at the times of survey. The males of moisture dependent groups such as millipedes have been collected in October and November from the Great Western Woodlands (Car & Harvey, 2014) and spring sampling is unlikely to have significantly biased survey results.

The process of aligning species collected in the 2015 survey with those from 2012 was compromised by limited access to specimens collected 2012 and lodged with the WAM. Every attempt was made to retrieve comparative material collected by ecologia Environment from the WAM but the mollusc and crustacean collections were closed. The following snail species were requested but unavailable for study: *Bothriembryon* cf. *sedgwicki*, *Bothriembryon* sp. nov. ‘Marda’, *Pleuroxia* sp. nov. 'Windarling Hill’, *Sinumelon kalgum* and *Sinumelon* cf. *tarcoolanum*.

A further limitation may be the lack of molecular work to confirm species identifications. The 2012 fauna report did not attempt any identification based on DNA sequence data although the proportion of juvenile and unidentified specimens was high (‘sp. indet.’ or ‘sp. juv.’ in the report). It should be noted that not all of the critical specimens could be retrieved from the WAM, preventing DNA work on the snail fauna and some arachnid species.

For the arachnids and crustaceans, Bennelongia Environmental Consultants used in-house taxonomic expertise to rectify some of the previous identification issues and were able to align many species based on somatic morphology when animals were juvenile or the wrong sex for identification. When species were collected as empty shells or fragments, as was the case with many snail species and isopods, morphology provided the only feasible method of identification.

Habitat

There are seven major SRE habitat types within the study area (**Figure 8-5**, **Appendix 8-B**), all of which have a moderate or high suitability for SRE species. The most extensive SRE habitat type in the Mt Manning area is the sandy plains habitat, consisting of predominantly shrubby vegetation or open eucalyptus woodland over yellow or red sands.

Several of the SRE habitat types are approximately coincident with habitat types for vertebrate fauna, such as BIF and iron-rich hills (rocky ridge), colluvial gravels and breakaways (mallee woodland on rocky plain and footslopes).

Banded Iron Formations and Iron Rich Hills

The Banded Iron Formations and Iron Rich Hills include the J5 and Bungalbin East deposits and is the main topological feature in the MMHARCP. These BIF have high prospectivity for both specialist and relict SRE species because they are topographically diverse and include a number of very suitable microhabitats such as south-facing gullies, water-runoffs, rocky breakaways, accumulations of scree and vegetation associations.

Colluvial Gravels and Breakaways

The Colluvial Gravels and Breakaways habitat type is closely associated with the BIF and surrounds outcropping BIF features in the MMHARCP, Mount Jackson, Mount Geraldine and Mount Manning. Such habitats may be suitable for SRE fauna that are otherwise found only on the BIF because they form a matrix in which such formations are embedded. Vegetation cover in this habitat type is taller than on the BIF and this leads to a high number of shaded and sheltered microhabitats that may support SRE communities, such as gullies running from the BIF and accumulations of rock boulders and scree. It is expected that this habitat type supports communities of mygalomorph spiders, snails, slaters and pseudoscorpions. Hence, prospectivity for SRE fauna is estimated to be high. Due to its localised nature and close association with BIF, there is potential for SRE species present in such habitats to be locally restricted.

Alluvial Channels and Floodplains

The Alluvial Channels and Floodplains habitat is widespread in the MMHARCP. Vegetation cover is mostly tall, although the floodplains are sometimes exposed and have limited capacity to retain moisture in summer. Microhabitats within the floodplains and around channels are diverse because vegetation associations are complex, organic matter is accumulated over long periods of time (although washed away periodically in the floodplains), and the underlying geology is diverse. It is expected that relictual SRE groups such as terrestrial slaters, some snails and millipedes will occur here and this habitat type has a moderate suitability for SRE fauna.

Woodlands on Sedimentary Rocks and Gravel

The Woodlands on Sedimentary Rocks and Gravel habitat is a widespread and common habitat type in the survey area and extends widely beyond the MMHARCP. The dominant vegetation type is closed Eucalyptus woodland, often with shrubby myrtaceous understory. Shade cover is generally denser than in the BIF and Colluvial Gravel habitats and there is usually a greater capacity to hold moisture.

This habitat type has high suitability for SRE fauna and this was confirmed by the 2012 fauna survey that indicates the presence of diverse communities of mygalomorph spiders, terrestrial slaters, snails, pseudoscorpions, centipedes and millipedes. It is noted, though, that this habitat type is well-connected within the MMHARCP and extends beyond the MMHARCP. Hence it is likely that SRE fauna collected in Woodlands on Sedimentary Rocks and Gravel are more widespread in the Great Western Woodlands and likely have ranges that extend well beyond the Proposal disturbance area.

Woodlands on Red or Yellow Sands

Woodlands on Red or Yellow Sands differs from the Woodlands on Sedimentary Rocks and Gravel in both substrate and vegetation associations. These woodlands are generally more open and vegetation associations are not as complex.

This habitat type has mosaic character and is interwoven with the Colluvial Gravel, the denser Woodlands on Sedimentary Rocks and Gravel and the more open Sandy Plains habitats that dominate the survey area. As a result of its open nature, Woodlands on Red or Yellow Sands habitat is less prospective for SRE species, although some species in the SRE Groups are likely to occur.

As this habitat is interconnected with other habitats, it is likely that any SRE species found in this habitat type will also occur in others, in particular the denser woodlands. In summary, this habitat type has a moderate suitability for SRE fauna and species present here are likely to be found in other habitat types in the survey area.

Sandy Plains

Sandy Plains is the most common and widespread habitat in the survey area. It is a relatively exposed habitat type with predominantly shrubby vegetation or open *Eucalyptus* woodlands over yellow or red sands. The Sandy Plains habitat does have moderate prospectivity for species in SRE groups, with the groups most likely to occur being mygalomorph spiders (in particular the family Nemesiidae), pseudoscorpions of the family Olpiidae and scorpions of the genus *Lychas*. Moisture-dependent SRE groups such as snails and millipedes are less likely to occur. Species in SRE Groups occurring in Sandy Plains are expected to be relatively widespread because of good habitat connectivity.

Calcretes

The Calcretes are the least common habitat type in the survey area but patches occur locally. The Calcretes are a poorly vegetated and exposed habitat but may contain specialist species such as pseudoscorpions and mygalomorph spiders. It has moderate suitability for SRE fauna.

SRE Invertebrate Assemblage

The survey recorded 449 specimens belonging to 80 species across seven SRE invertebrate groups. A total of 51 species (64 %) are potential SREs according to WAM's framework and two species (2 %) are confirmed SREs. Of the 53 potential or confirmed SRE species, 47 were collected outside, or both inside and outside, of the proposed Proposal disturbance area and six were only recorded within the disturbance area (**Figure 8-5**).

The mygalomorph spider group was the most diverse (25 species/6 families) followed by terrestrial slaters (12 species), pseudoscorpions (7 species); snails (four species), scorpions (two species), centipedes (two species) and millipedes (one species).

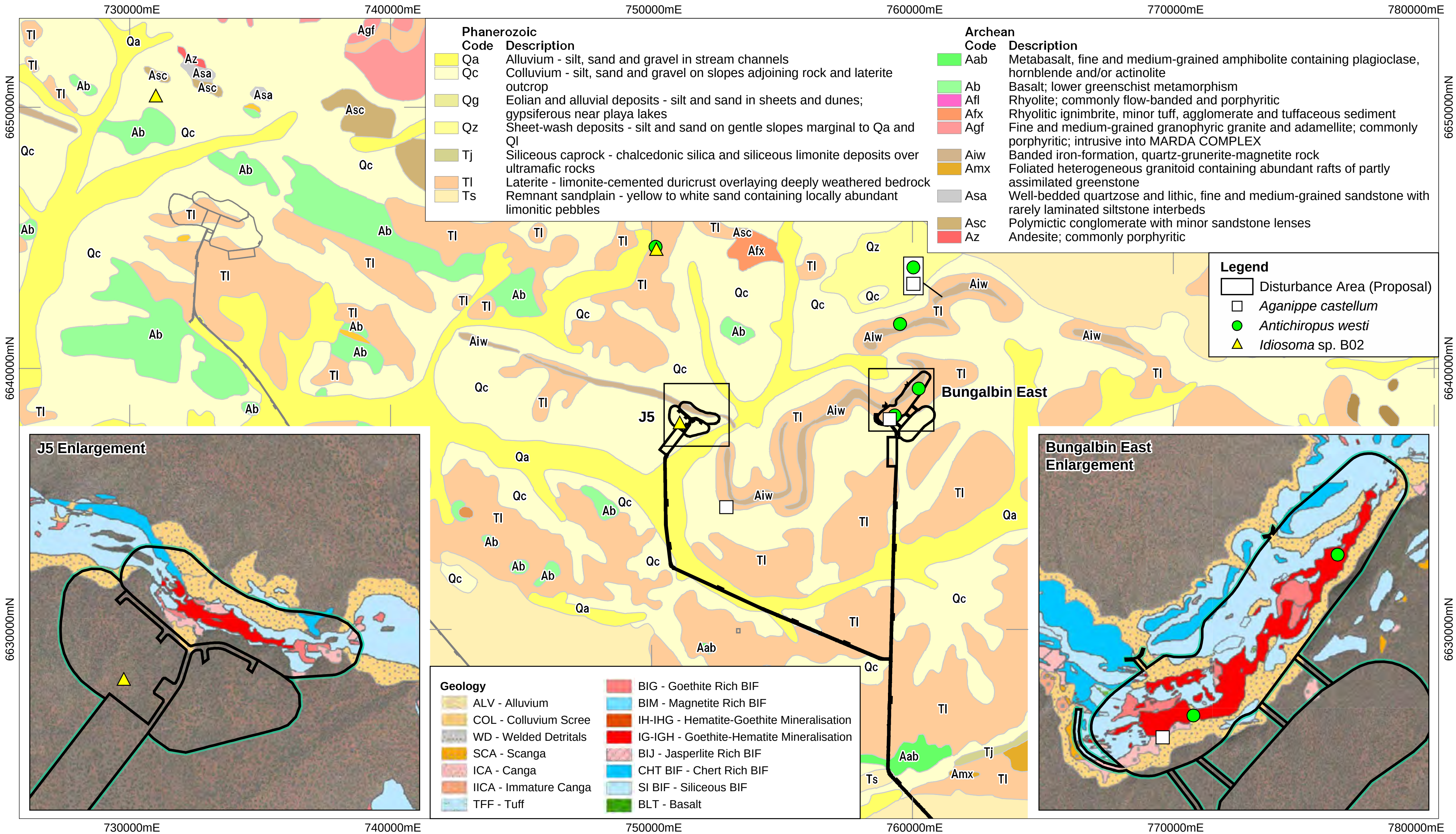
Within the mygalomorph spider group the most commonly recorded family was the true trapdoor spiders (Idiopidae) followed by the wishbone spiders (Nemesiidae), brush-footed trapdoor spiders (Barychelidae), mouse spiders (Actinopodidae), trapdoor spiders from the Ctenizidae family and funnel-web spiders (Dipluridae).

Conservation significant species

The surveys undertaken in 2012 and 2015 recorded one listed invertebrate species (*Aganippe castellum* - Tree-Stem Trapdoor Spider; Priority 4), 51 potential SRE species and two confirmed SRE species (the spider *Idiosoma* sp. B02 and the millipede *Antichiropus westi*) (**Table 8-4**). All three of these species were recorded within and outside the Proposal disturbance area (**Figure 8-6**).

TABLE 8-4: LISTED OR CONFIRMED SRE SPECIES RECORDED DURING THE SURVEY

Taxonomic Group	Species	Status	Location	Site	Habitat Type
Spiders	*Aganippe castellum*	Priority 4	Bungalbin East, Regionally north of BE, South of HAR	21, 25, 29	BIF and Iron Rich Hills, Colluvial Gravels, Woodlands on Red and Yellow Sands
	Idiosoma sp. B02	Confirmed SRE	J5, North and North-east of J5	06, 15, 18	Colluvial Gravels, Woodlands on Red and Yellow Sands
Millipedes	*Antichiropus westi*	Confirmed SRE	BE, North of J5 and North of BE	19, 22, 23, 25, 28	BIF and Iron Rich Hills, Colluvial Gravels, Woodlands on Red and Yellow Sands



Source: Infrastructure supplied by Mineral Resources (July 2016)
Lithology supplied by Mineral Resources (Mar 2016)
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Imagery: Landgate (2012)

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CAD Ref: g2378_J5_BE_PER_C08_F06
Date: July 2016 | Rev: C | A4

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DISTRIBUTION OF LISTED OR CONFIRMED SRE SPECIES

Figure:
8-6

Of the 51 potential SRE species, six species have only been found inside the disturbance area, comprising four mygalomorph spiders, one pseudoscorpion and one snail (**Figure 8-7**): Further details of these six species and their likely ranges are provided in **Table 8-5**. The ranges and potential threat to these six species are discussed in **Section 8.3.1**, together with the potential threat to listed and confirmed SRE species. Information about the ranges of other potential SRE species is given in **Appendix 8-B**.

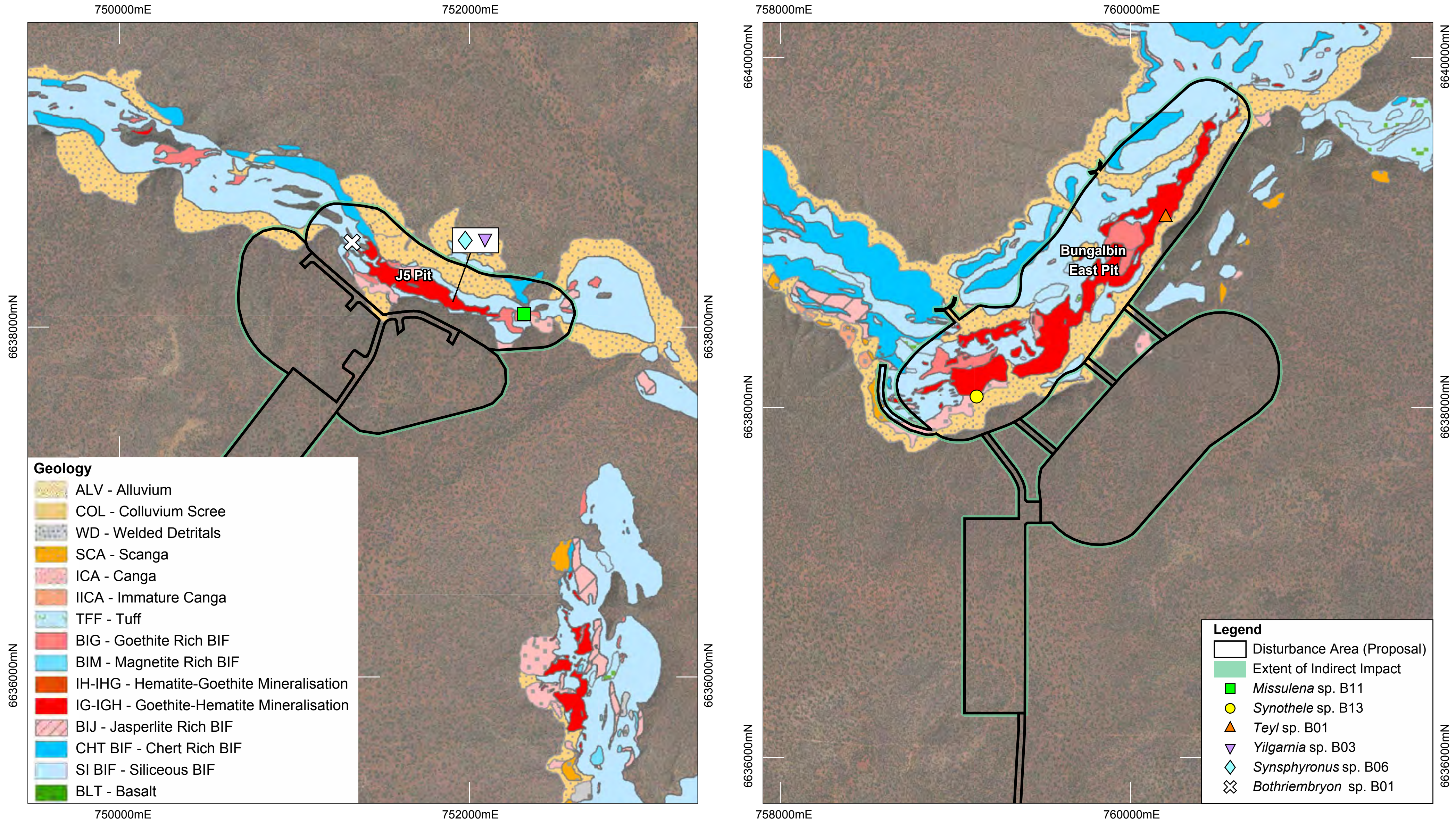
TABLE 8-5: POTENTIAL SRE SPECIES KNOWN ONLY FROM THE DISTURBANCE AREA

Taxonomic Group	Species	Location	Site	Habitat Type	Minimum linear range
Spiders	*Missulena* sp. B11	J5	J5RC105	BIF with colluvial scree	11.5 km
	Synthole sp B13	BE	21	BIF slopes with scree and gully	11.0 km
	Teyl sp. B01	BE	30	BIF hill with gully and outcrops	11.0 km
	Yilgarnia sp. B03	J5	04	BIF ridge with major outcrops	11.5 km
Pseudo-scorpions	*Synsphyronus* sp. B06	J5	04	BIF ridge with major outcrops	11.5 km
Snails	*Bothriembryon* sp. B01	J5	05	BIF ridge with major outcrop	>20 km

8.3 Assessment of potential impacts

The potential impacts of the Proposal on terrestrial vertebrate and short-range endemic invertebrate fauna are:

- loss or fragmentation or change in the condition of fauna habitat, especially with regard to:
    - vegetation clearing
    - disruption to nutrient and water collection, run-off and hydrological regimes
    - introduction and spread of weeds
    - altered fire regimes
    - introduction of artificial food and/or water sources.
- displacement, injury and/or death of fauna individuals during construction and thereafter as a result of:
    - changes to feral animal populations
    - increased vehicle movements
    - dust
    - noise and vibration
    - lighting.



Note
Infrastructure supplied by Mineral Resources (July 2016)
Fauna supplied by Bennelongia Env. Cons. (July 2016)

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CAD Ref: g2378_J5_BE_PER_C08_F05

Date: July 2016 | Rev: C | A4

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POTENTIAL SRE SPECIES KNOWN ONLY FROM THE DISTURBANCE AREA

Figure: **8-7**

8.3.1 Direct impacts

The predicted extent of impact on fauna has been assessed at regional and local scales with respect to clearing/removal of fauna habitat for conservation significant vertebrate species, vertebrate species likely to be significantly dependent upon BIF habitat and listed invertebrate and SRE invertebrate species.

The extent of habitat clearing within the ecologia Environment (**Appendix 8-A**) study area is quantified in **Table 8-6**. The potential effects of habitat clearing are discussed below having regard for habitat type and the species of interest.

TABLE 8-6: EXTENT OF HABITAT LOSS DURING CONSTRUCTION AND MINING

Habitat Type	Extent in study area		Habitat loss		Remaining Extent	
	Ha	%	Ha	%	Ha	%
Vertebrate						
Rocky ridge	1,497.9	2.6	145.2	9.7	1,352.3	90.3
Mallee woodland on rocky footslope	13,084.8	22.4	277.0	2.1	12,807.8	97.9
Mixed Eucalypt woodland on plain	36,047.1	61.9	171.1	0.5	35,875.8	99.5
Sandy plain with shrubland	6,912.9	11.9	13.1	0.2	6,899.5	99.8
Invertebrate/SRE						
BIF and iron-rich hills	5446.0	0.5	141.5	2.6	5,304	97.4
Colluvial gravels and breakaways	131,477.5	12.3	217.8	0.2	131,260	99.8
Alluvial channels and floodplains	538.8	0.05	0.0	0	539	100
Woodlands on sedimentary rocks and gravel	118,266.7	11	18.6	0.0	118,248	100
Woodlands on red or yellow sands	415,931.4	38.8	215.9	0.1	415,734	99.9
Sandy plains	318,376.4	29.7	4.7	0.0	318,378	100
Unclassified (southern haul road)	-	-	7.9	-	-	-

Rocky ridge habitat

Terrestrial fauna of the rocky ridge habitat are diverse due to the large amount of shelter and hiding spaces between rock piles and in crevices and small caves. The associated fauna of interest are:

- Woolley's Pseudantechinus
- Peregrine Falcon
- Slender Blue-tongue
- Tree-stem Trapdoor Spider
- *Antichiropus westi* (millipede)
- *Missulena* sp. 11

- *Yilgarnia* sp. B03
- *Synsphyronus* sp. B06
- *Bothriembyron* sp. B01

Woolleys Pseudantechinus

Woolley's Pseudantechinus is a small carnivorous marsupial found in the Pilbara, Ashburton, Murchison and Coolgardie bioregions. It was recorded by ecologia Environment via secondary evidence (scats) and has been recorded previously from other surveys within 35 km of the Proposal (**Appendix 8-A**). These records represent the southern-most extent of this species' distribution. Habitat for this species occurs across multiple regions within WA, and it is not specially protected under either Commonwealth or WA legislation. The Proposal will not have a significant impact on this species.

Peregrine Falcon

The Peregrine Falcon is a bird of prey that occurs most commonly near cliffs along coasts, rivers and ranges and also around wooded watercourses and lakes. Its distribution is widespread in many parts of Australia and some of its continental islands but is absent within deserts and the Nullarbor Plain. The species feeds almost entirely on birds, especially parrots and pigeons. It nests primarily on ledges, cliffs, granite outcrops and in quarries but sometimes within tree hollows around wetlands or in other areas where appropriate elevated, rocky nesting sites are limited or absent in the landscape.

The Peregrine Falcon was recorded by ecologia Environment within the rocky ridge habitat type west of J5. It also potentially nests and breeds on cliffs within the HAR but no observations of this were made by ecologia Environment during the field surveys. It also inhabits the mixed eucalypt woodland habitat and was recorded by ecologia Environment in proximity to J5 within this habitat type.

The Peregrine Falcon is protected under Schedule 7 of the WC Act (WA), meaning that it is in need of protection but is not likely to become extinct, nor is subject to an agreement between Australia and Japan relating to the protection of migratory birds. The Proposal will not have a significant impact on this species.

Slender Blue-tongue

The Slender Blue-tongue is a medium-size lizard that inhabits sandy or rocky arid and semi-arid areas, particularly with abundant Spinifex grass. The species is widespread throughout its habitat.

It was recorded by ecologia Environment (Appendix 8-A) and by numerous previous surveys within 35 km of the study area.

The Slender Blue-tongue is not specially protected under Commonwealth or WA law. The Proposal will not have a significant impact on this species.

Tree-stem Trapdoor Spider

The Tree-stem Trapdoor Spider (*Aganippe castellum*) is a listed species (Priority 4). It is a medium-sized spider that inhabits burrows with an above-ground entrance at the base of myrtaceous shrubs, typically in drainage areas of water run-off and gullies with sandy loam soils. Its distribution is limited to the south-west of WA as far north as Morawa Shire, south to Merredin and east to Southern Cross (Inglis, 2008).

The Tree-stem Trapdoor Spider is moderately widespread in the Wheatbelt and Southern Yilgarn and occurs widely throughout in the survey area. It was collected from Bungalbin East inside the disturbance area, but also to the south west and north east, along the ridge (**Figure 8**

6). It has previously been recorded at Koolyanobbing Range and Mt Jackson Range, with population estimates ranging from 44,000 individuals (Koolyanobbing) to 200,000 individuals (Mt Jackson).

At the HAR, the Tree-stem Trapdoor Spider appears to be confined to the BIF and breakaway habitats and is absent from the woodlands and sand plains surrounding these formations. On the ridges it is locally common on south-facing, eastern and western slopes although distribution is patchy and localised.

The Tree-stem Trapdoor Spider is listed as Priority 4 Fauna by DPaW, meaning it is considered to be rare but not threatened, near-threatened or (as in the case of *Aganippe castellum*) has been removed from the list of threatened species within the last five years for a reason other than taxonomy. Loss of habitat within the Proposal disturbance area is unlikely to affect the conservation status of *Aganippe castellum*. Therefore, the Proposal will not have a significant impact on this species.

Missulena sp. B11

A juvenile specimen of the spider genus *Missulena* was collected in a shallow troglofauna trap at borehole J5RC105 on the J5 deposit during Bennelongia Environmental Consultants' recent troglofauna survey in November 2015 (**Figure 8-5**, **Appendix 8-B**). This site was located in the BIF and Iron Rich Hills habitat.

The specimen is included in the species list as it is clearly a surface species that was collected as bycatch. It is morphologically similar to *Missulena* sp. B09 and may be the same species, but has fewer cuspules on the pedipalp coxae, the rastellum on the chelicerae has fewer spines, and the body cuticle is generally darker. In the absence of genetic data this specimen is conservatively recognised as a separate *Missulena* species.

It is presently known only from the impact areas at J5 and is a potential SRE species based on previous research; however, *Missulena* sp. B11 is expected to have a linear range that is as least as wide as the BIF upon which it has been found (11.5 km). *Missulena* species can be quite widespread (Miglio, et al., 2014) and it is possible that the actual range of this species is much wider than estimated. Thus, the range of the species almost certainly extends outside the proposed Proposal disturbance area and it will not be affected significantly by the Proposal.

Yilgarnia sp. B03

A single female spider was collected from within the Proposal disturbance area at J5 on BIF breakaways and ridges (**Figure 8-5**).

Although only known from a single female, this specimen does not match the male of Yilgarnia 'MYG272' (WAM T126965) that was collected in the 2012 survey. The specimens differ in abdominal patterning, the number of cuspules on the pedipalp coxae, and the shape and number of cuspules on leg coxae III and IV. These differences are unlikely a result of sexual dimorphism. Thus, *Yilgarnia* sp. B03 is most likely a new record for the survey area.

Species of *Yilgarnia* occur commonly throughout the Goldfields and Pilbara bioregions of WA and there is evidence that there are many undescribed species with restricted ranges (Main, 2008; Castalanelli, et al., 2014). Based on research and expertise, *Yilgarnia* sp. B03 is classified as a potential SRE species. Locally the species is likely to occur more or less continuously through 10 km of BIF that runs north-west of J5 and is not intersected by major gullies or gorges that would be expected to restrict dispersal. Loss of habitat within the Proposal disturbance area is unlikely to affect the conservation status but its exact distribution is unknown. Therefore the Proposal is unlikely to have a significant impact on this species.

Synsphyronus sp. B06

The pseudoscorpion *Synsphyronus* sp. B06 is also a singleton species and was collected from the same site as *Yilgarnia* sp. B03. This pseudoscorpion is the largest species of

Synsphyronus collected from the sites sampled and is almost twice the size of *Synsphyronus mimulus*. *Synsphyronus* pseudoscorpions are habitat specialists that live under rock boulders, in rocky crevices and under scree (Harvey, 2010; 2012).

Synsphyronus sp. B06 may be restricted to the wider J5 deposit because it has not been sampled at Bungalbin Hill or Bungalbin East despite other *Synsphyronus* species being present at these locations. Thus, this species is a potential SRE species based on research. However, the distribution of *Synsphyronus* sp. B06 is likely to follow the geological formation upon which it has been found, which extends for 11.5 km. This is considered to comprise the minimum linear range of the species, such that the species will almost certainly occur outside the proposed Proposal disturbance area. Thus, the species will not be affected significantly by the Proposal.

Antichiropus westi (a species of millipede)

Antichiropus westi is a millipede that inhabits rocky ridges and woodlands. Its distribution is quite widespread with many records from Mt Gibson in the Midwest Region as well as Mt Jackson, Mt Manning, Koolyanobbing, HAR and Mummaloo (Car & Harvey, 2014).

This species was recorded by Bennelongia Environmental Consultants (**Appendix 8-B**) within both the rocky ridge habitat type (equivalent to SRE habitat type BIF and iron-rich hills) and the mixed eucalypt woodland habitat type (equivalent to the SRE habitat type woodlands on red and yellow sands). It was recorded both within and outside the disturbance areas.

This species is a confirmed SRE species according to the 10,000 km2 range criterion, although it is widely distributed. It has a linear range of about 140 km. Loss of habitat within the Proposal disturbance area is unlikely to affect the conservation status of Antichiropus westi. Therefore the Proposal is unlikely to have a significant impact on this species.

Bothriembron sp. B01

A single shell of a snail, *Bothriembryon*, was collected at Site 05 in the Proposal disturbance area within Open Eucalyptus woodland. It differs from *Bothriembryon* aff. sedgwicki collected elsewhere in the area, in having a much shorter spiral. *Bothriembron* sp. B01 may be the same species as *Bothriembryon* sp. 'Marda', which was collected in the 2012 fauna survey (ecologia 2014). However, no specimens of the latter species were available for comparison.

Many species of *Bothriembryon* have narrow ranges (Breure & Whisson, 2012) and *Bothriembryon* sp. B01 is currently treated as a potential SRE species based on research and expertise.

Bothriembryon sp. 'Marda' was also recorded from the proposed pit at J5, but also more widely including areas of mixed woodlands to the south and outside the pit areas to the west near Bungalbin East. It is considered likely that the snail *Bothriembron* sp. B01 occurs outside the proposed impact areas at J5 and loss of habitat within the Proposal disturbance area is unlikely to affect the conservation status for this species. Therefore the Proposal is unlikely to have a significant impact on this species.

Mallee woodland on rocky plain and footslopes habitat

This habitat type supports generalist vertebrate fauna species, with species of interest including:

- Little Woodswallow
- Shy Heathwren
- Western Yellow Robin
- *Synthole* sp. B13
- *Teyl* sp. B01

Little Woodswallow

The Little Woodswallow is a small bird that inhabits open woodland, especially in areas with rocky outcrops or gorges. It is widely distributed across Australia.

This species was recorded by ecologia Environment in the vicinity of the HAR. This record is consistent with the southern limit of this species' typical distribution.

The Little Woodswallow is not specially protected under either Commonwealth or WA legislation. The Proposal will not have a significant impact on this species.

Shy Heathwren

The Shy Heathwren is a small bird inhabiting shrubland and mallee woodland with a dense understorey. As described previously, it is found within WA's Wheatbelt region and as far east as Cocklebiddy.

The species was recorded by ecologia Environment from the sandy plain with shrubland habitat type and has previously been recorded within 35 km of the study area. These records represent the northern limit of this species' typical distribution.

The Shy Heathwren is not specially protected under either Commonwealth or WA legislation. The Proposal will not have a significant impact on this species.

Western Yellow Robin

The Western Yellow Robin is a small bird that inhabits sclerophyll forests and woodlands but also mallee vegetation, usually where there is a shrub understorey and large amounts of leaf litter on the ground. The Western Yellow Robin's distribution is mainly in south-western Australia, from Shark Bay in the north to the Nullarbor Plain in the east (Birdlife Australia, 2016).

This species was recorded by ecologia Environment within the rocky ridge habitat type, but it is more often found on the lower BIF slopes in areas of denser vegetation along gullies (Department of Environment and Conservation, 2007).

The Western Yellow Robin is not specially protected under either Commonwealth or WA legislation. The Proposal will not have a significant on this species.

Synothele sp. B13

Two females of this diverse spider genus were collected in the proposed disturbance area at Bungalbin East (**Figure 8-5**) within the BIF slopes with scree and gully habitat. An additional juvenile of this species (WAM T130697) was also collected in the 2012 survey from Bungalbin East in the disturbance area.

The specimens differ morphologically from *Synothele howi* that has been collected previously in the MMHARCP (Raven, 1994; ecologia Environment, 2014b) and are likely to represent a new species. *Synothele* is widespread in Australia and includes mostly undescribed species, many of which have very short ranges (Raven, 1994; Castalanelli, et al., 2014).

Synothele sp. B13 is classified here as a potential SRE species based on research and expertise. However, the species is almost certain to occur more widely on rocky breakaways and outcrops at Bungalbin East and Bungalbin Hill, in the same way as other mygalomorph spiders such as *Aganippe* sp. B19 and *Aganippe castellum*. The minimum range of this species is estimated to be 11 km but it almost certainly extends farther and is expected to encompass the BIF slopes located north-east of Bungalbin East. Thus, the species will not be affected significantly by the Proposal

Teyl sp. B01

A single female spider specimen of *Teyl* was collected from Site 30 in the Proposal disturbance area at Bungalbin East within the BIF hill with gully and outcropping habitat (**Figure 8-5**).

This is the first record of *Teyl* in the MMHARCP although the genus is widely distributed in south-western Australia, with many records from the southern Goldfields forming an extensive radiation of numerous undescribed species (Burbidge, et al., 1999). The collected female differs from *Teyl luculentus*, *Teyl* 'MYG021' and *Teyl* 'MYG217' in a number of morphological characters, including the number of cuspules on the pedipalp coxae. The Minnivale Trapdoor spider *Teyl* sp. is listed as Critically Endangered under the WC Act 1950 (Burbidge, et al., 1999) and many other described species have short ranges.

Teyl sp. B01 is therefore classified as a potential SRE species based on research and expertise. Its linear range is expected to encompass Bungalbin Hill and Bungalbin East as there are no obvious limitations to dispersal. Consequently, the estimated minimum range is 11 km, which includes areas outside the proposed Proposal disturbance area. Thus, the species will not be affected significantly by the Proposal.

Mixed Eucalypt woodland habitat

This habitat type is likely to support the highest fauna species diversity due to the greater structural complexity of vegetation including tall trees that provide hollows, logs (wood debris) and habitat for arboreal species. Species of interest that occur within this habitat type are:

- Rainbow-Bee eater
- Peregrine Falcon
- Fork-tailed Swift
- Western Yellow Robin
- *Idiosoma* sp. B02 (spider)
- *Antichiropus westi* (a species of millipede)

Rainbow Bee-eater

The Rainbow Bee-eater is small bird that inhabits a variety of different habitat types including open forests, woodlands and shrub lands as well as cleared areas (usually near water (Birdlife Australia, 2016). The Rainbow Bee-eater is widespread throughout Australia, except in desert areas, and is also found in eastern Indonesia, New Guinea and, rarely, the Solomon Islands (Birdlife Australia, 2016).

This species was recorded by ecologia Environment both within and beyond the disturbance area for the Proposal, and from previous surveys elsewhere in the region. Breeding habitat was not recorded within the disturbance area, although foraging habitat is present.

Its conservation status (Migratory; Schedule 3) means that it is specially protected under both Commonwealth and WA legislation by virtue of its listing in the Japan-Australia Migratory Bird Agreement (JAMBA).

Although it has protected status, the species is widespread and abundant in Australia and, besides the specific circumstances of competition with and predation by Cane Toads in northern Australia, is not subject to any known threats (Department of the Environment, 2016). The Proposal will not have a significant impact on this species.

Fork-tailed Swift

The Fork-tailed Swift is a small bird with no specific habitat preference as it lives a nomadic, almost exclusively aerial lifestyle. The species is distributed from central Siberia (Russia), throughout Asia, to New Guinea and Australia.

The Fork-tailed Swift was recorded by ecologia Environment from the mixed eucalypt woodland habitat type (hence its inclusion here) and although the study area is within the species' range it does not utilise the habitat of the study area (DPaW, 2015 cited in ecologia Environment **Appendix 8-A**).

Its conservation status (Migratory; Schedule 3) means that it is specially protected under both Commonwealth and WA legislation by virtue of its listing in the JAMBA. The Proposal will not have a significant impact on this species.

Idiosoma sp. B02

This undescribed species of spider inhabits woodland areas and its distribution is limited to the Koolyanobbing and Helena-Aurora ranges (M. Rix, pers. comm. cited in **Appendix 8-B**). *Idiosoma* sp. B02 belongs to the *Idiosoma nigrum* complex. Accordingly, although it is known to be a different species from the listed *Idiosoma nigrum*, it is requested that it should be treated as the threatened *Idiosoma nigrum* for assessment purposes until the WA Museum has completed a taxonomic revision of *Idiosoma*. The Department of Parks and Wildlife will assess the conservation status of all new species in the I. *nigrum* complex as soon as possible after completion of the revision.

Current information suggests that *Idiosoma* sp. B02 has a relatively restricted geographic distribution in comparison to some of the other new species within the I. *nigrum* complex. However, it was recorded by Bennelongia Environmental Consultants both within and outside the disturbance area, within the mixed eucalypt woodland habitat type (equivalent to the woodland on sedimentary rocks and gravel SRE habitat type).

It is a confirmed SRE species on the basis of its limited distribution. Loss of habitat within the Proposal disturbance area is unlikely to affect its conservation status.

Sandy plain with shrubland habitat

This habitat type occurs in the south of the study area, including the southern end of the Bungalbin East haul road (**Figure 8-2**). This habitat is used by numerous species that use the soft substrate to construct burrows. Species of interest include:

- Malleefowl
- Shy Heathwren

Malleefowl

The Malleefowl is a large, ground-dwelling bird that inhabits thickets of mallee, mulga or other dense litter-forming shrublands as well as dry forest dominated by other eucalypt and acacia species ((Johnstone & Storr, 1998; Benshemesh, 2005).

This species was once common and widespread across semi-arid southern Australia but has declined severely both in terms of abundance (20 % decrease) and area of occupancy (50 % decrease) (Garnett & Crowley, 2000; Benshemesh, 2005).

This species was recorded by ecologia within the sandy plain with shrubland habitat type located in the south western extremity of the study area, via secondary evidence in the form of recently used mounds (1-5 years old). No active mounds were recorded within the study area, despite extensive searches undertaken as part of both flora and fauna surveys conducted over the period 2012-2014. In addition to the mounds, fresh tracks of the species were detected during the field survey and one individual was sighted opportunistically approximately 8 km east from the study area eastern boundary (**Appendix 8-A**).

There are numerous records of this species' occurrence within 100 km of the study area, particularly further west towards the Mt Jackson Range.

The Malleefowl is listed as a Threatened (Vulnerable) species under the EPBC Act, meaning that the species is likely to become endangered within the next 25 years unless threats to its survival are abated. The species is also listed in Schedule 3 (Vulnerable) of the WC Act, meaning that it is in need of special protection without which it is likely to become extinct.

The Malleefowl may also be recorded in the Mallee woodland on rocky plain and footslopes habitat.

The Proposal will not have significant impact on this species.

Drainage line

This habitat is not sufficient to attract waterbird species but may attract additional species from surrounding areas when water is available. Species of interest include the Rainbow Bee-eater.

Seasonal swamp habitat

This habitat type has a small extent and is unlikely to support conservation significant wetland fauna species. There are no other species of interest associated with this habitat type.

8.3.2 Indirect impacts

Aspects of the Proposal during both construction and operations phases have the potential to introduce environmental effects beyond those experienced directly as a result of clearing of fauna habitat. Indirect impacts on fauna and associated habitat that may occur through implementation of the Proposal include the effects of vegetation degradation, fire, noise, light, vehicle strike, food waste and open water.

Vehicle strike

The construction and operation of haul roads, light vehicle roads and access tracks within the disturbance area will increase the likelihood of vehicles and/or machinery striking native fauna. Small reptiles may be injured or killed on roads while basking during the day and mammals may be injured or killed on roads, particularly at dawn and dusk. Injured or dead animals attract scavenging species such as the Wedge-tailed Eagle, which are then more likely to be struck themselves.

Light and noise emissions can be advantageous to some species, for example those that feed on insects around lights, and disadvantageous to others, such as bats whose echolocation calls may be disrupted by artificial background noise (Zagorodniuk, 2003 cited in ecologia Environment, 2014). Light and noise emissions may also attract feral predators as they associate human activity with food resources. An increase in feral predators will likely cause an increase in predation rates on native fauna.

Of the species of interest identified in the preceding sections, Malleefowl are at greatest risk of being struck due to their ground-dwelling nature. However there are relatively few individuals within the area surrounding the Proposal and no readily identifiable populations.

Short Range Endemic species are largely restricted to the vicinity of their burrows, only travelling limited distances when required. Thus, while there may be some additional impact from potential vehicle strikes, these are expected to be minimal.

Noise, vibration and light emissions

Noise, vibration and light emissions will occur throughout the disturbance area as a result of mining activities (drilling, blasting, machinery and vehicle movements) and ore haulage. The levels of these emissions will vary depending on the particular phase of the Proposal (construction, operation and closure), with construction phase emissions being temporary in duration for a period of about 12 months.

Regardless of the phase of the Proposal, such emissions may cause vertebrate fauna species to move away from the area, alter their behaviour, or change community structure (Larkin 1996; Raddle 1998). While the impact of noise, vibration and light is not well documented for SRE species, it is likely that these indirect effects may impact populations located close to the source of the disturbance (e.g. road, mine infrastructure, light sources). SRE species are unable to move significant distances to avoid such disturbances although effects of noise, vibration and light emissions are likely to dissipate rapidly with distance from the source and are not considered to be a significant risk to SRE species.

Over time it is expected that most vertebrate species will either habituate to the dust, light and noise associated with mining operations, or move to a suitable distance away from the source so that they are no longer disturbed (Larkin, 1996; Radle, 1998 cited in ecologia Environment, 2014). Due to the large areas of relatively undisturbed habitat north and south of the disturbance area and the mobility of most species, individual animals should be able to move away from dust, light, noise and vibration sources and thus avoid these impacts.

Habitat degradation

Dust emissions and weed invasion may result in localised degradation of vegetation to the extent that faunal assemblages are affected through a reduction in both food and habitat resources.

Localised increased dust emissions above natural background levels is likely to occur as a result of clearing of vegetation during construction, as well as blasting and vehicle movements once the mine is operational. Dust emissions are likely to be greatest during the construction phase when land clearing for the mines and haul roads is taking place.

Dust emissions will progressively reduce once the haul roads are sealed along their entire length, land clearing is scaled back to those operations necessary to run the mines, and as the pit wall heights increase and cleared areas undergo natural stabilisation.

Fire

Although fire is a natural process, an increase in fire frequency and/or severity has the potential to indirectly impact fauna and its associated habitat. Increased human activity is correlated with increased fire risk and/or altered fire regimes.

Fire can lead to temporary destruction of fauna habitat or more lasting degradation if native vegetation if, for example, fire frequency increases. Some species are sensitive to fire, such as Malleefowl, which tend to inhabit areas that are at least 40 years post-fire.

Movement of vehicles, machinery and human influences may increase the frequency of spot fires, particularly in the flammable sandy plain with shrubland due to its dense vegetation including grasses that are dry for much of the year. Consequently, fire management is necessary to prevent and manage unplanned fires.

Open water and food waste

The presence of open water sources and accessible food wastes can lead to an increase in feral fauna numbers and allow these species to occur in areas they would otherwise not occupy. An increase in feral fauna densities will have an increased negative impact on the abundance and diversity of native fauna due to increased predation pressure and resource competition. The creation of tracks and other access corridors can also increase penetration of feral predators into otherwise undisturbed areas.

Water resources include water sumps and any areas where excess water accumulates and water sources not often associated as such, e.g. water tanks can attract feral European honey bees which may also affect the health and safety of Proposal personnel. Food wastes are typically concentrated around accommodation camps (such as poorly disposed kitchen scraps), however poorly disposed lunch scraps from personnel working away from the camp can also provide a food resource for feral fauna species.

8.4 Proposed environmental management

Direct loss of habitat through clearing will have the largest impact on terrestrial fauna and SRE invertebrate fauna. Options for avoidance of habitat clearing are constrained by the location of the mineralisation and the disturbance area has been reduced to smallest extent possible whilst retaining some flexibility to adjust the haul road alignment as may be required. Refer to **Section 2.6** for a discussion on alternatives to the Proposal.

Given the limited opportunities to avoid and/or further reduce the extent of habitat clearing, MRL has focussed its management efforts on indirect impacts to ensure that impacts are not greater than predicted, and that the Proposal is implemented in a manner that is sensitive to the surrounding environment.

Indirect impacts to vertebrate and SRE invertebrate fauna can be effectively managed through implementation of MRL's Environmental Management System (EMS) for the Proposal, which includes plans and procedures relevant the management of fauna (**Table 8-7**). The EMS for the Proposal will be certified and maintained to the international standard AS/NZS ISO 14001:2004.

TABLE 8-7: MANAGEMENT OF FAUNA – MRL PLANS AND PROCEDURES

Doc. No	Title	Description
MRL-EN-POL-0001	Environment and Community	Company policy in relation to the environment and communities.
MRL-EN-PLN-0003	Rehabilitation and Mine Closure Plan	Outlines the approach, objectives and completion criteria for rehabilitation of habitat and mine closure.
MRL-EN-PLN-0001	Environmental Management Plan	Outlines the systematic approach to environmental management.
MRL-EN-PRO-0001	Fauna Management	Describes procedures for management of native fauna
MRL-EN-PRO-0004	Land Clearing	Describes procedures to be used when clearing land after a Site Disturbance Permit has been issued.
MRL-EN-PRO-0005	Site Disturbance Permit	Describes the system of checks to be undertaken and approved prior to any ground disturbance.
MRL-EN-PRO-0007	Weed hygiene and control	Describes the approach to preventing the introduction and/or spread of weeds.
MRL-EN-PRO-0009	Land rehabilitation	Describes the main considerations when rehabilitating land after mining and related disturbance.
MRL-EN-PRO-0012	Dust Management	Describes the general requirement to suppress dust generation from mining and processing activities.

Doc. No	Title	Description
MRL-OHM-PRO-0007	Incident Reporting	Outlines MRL's requirements in regard to incident classification and required timeframes for the reporting of incidents by impact type and actual and potential consequence level.

In respect of vehicle strike, open water and food waste, routine fauna controls will be implemented as outlined in MRL-EN-PRO-0001 as well as the Rehabilitation and Mine Closure Plan. These controls include:

- induction and training for all site personnel on fauna occurrence, obligations and management, including the need for qualified fauna handlers
- fencing of all dams and fauna egress matting for dams lined with High-Density Polyethylene (HDPE) that prevents animals from escaping the water
- prohibition on handling animals unless qualified and on feeding animals
- storage of food and disposal of organic waste such that it does not create sources of food
- adherence to all speed limits, removal of any dead fauna (road kill) and prohibition on driving outside the disturbance area without an approved Site Disturbance Permit
- removal of all dams and associated water infrastructure such that there will be no permanent water sources once mining is complete

In respect of habitat degradation from weeds and dust, routine weed hygiene and dust controls will be implemented, as outlined in MRL-EN-PRO-0007 and MRL-EN-PRO-0012. These controls include:

- inspection of light vehicles and heavy machinery entering the site, especially prior to and during construction - any vehicle or machinery that is not free of mud or soil, vegetation debris, seeds, fauna) will be quarantined for cleaning prior to use
- control of weeds observed during site inspections or monitoring.

In respect of habitat loss from fire, MRL will not conduct any burning of vegetation or allow activities that carry risk of inadvertent fire, such as welding and grinding, without an approved permit (MRL-OHM-PER-0011 Hot Work Permit).

Rehabilitation undertaken in accordance with the Rehabilitation and Mine Closure Plan will partially return habitat cleared by the Proposal, primarily in areas where the topography has not been heavily modified (i.e. supporting infrastructure areas and haul roads).

The management plans and procedures outlined above are expected to assist MRL's management of threatened fauna such as Malleefowl, and to this extent the Proposal is consistent with the National Recovery Plan for this species (DEH, 2007). Specific management procedures of relevance to Malleefowl include:

- reduction of fire threat to Malleefowl habitat through appropriate fire prevention and management strategies
- inclusion of information on malleefowl conservation and management information will as part of site environmental inductions
- installation of road signs to alert personnel when they are entering Malleefowl habitat
- reporting of Malleefowl sightings to DPaW (fauna interaction).

8.5 Residual impact

The residual impacts of the Proposal on vertebrate and SRE invertebrate fauna, once all efforts to avoid, minimise and rehabilitate the proposed extent of disturbance have been considered, are:

- loss of high quality habitat for several species that are specially protected under either the EPBC Act, the WC Act, DPaW Priority Fauna list, or both:
  - Malleefowl (EPBC Act – Threatened; WC Act – Schedule 3/Vulnerable)
  - Tree-stem Trapdoor Spider (DPaW - Priority 4)
  - Rainbow Bee-eater (EPBC Act - Migratory, WC Act – Schedule 5/Migratory)
  - Fork-tailed Swift (EPBC Act – Migratory; WC Act – Schedule 5/Migratory)
  - Peregrine Falcon (WC Act – Schedule 7/Other)
- loss of high quality habitat for other non-listed species that are at the limit of their distribution and/ or appear reliant on such habitat for survival:
  - Little Woodswallow
  - Western Yellow Robin
  - Woolley's Psuedantechinus.
- Loss of high quality habitat for four listed and confirmed SRE invertebrate species and six potential SRE species known only from the disturbance area but likely to be more widespread:
  - *Aganippe castellum* (Priority 4)
  - *Idiosoma* sp. B02
  - *Antichiropus westi*.
  - *Missulena* sp. B11
  - *Synthole* sp B13
  - *Teyl* sp. B01
  - *Yilgarnia* sp. B03
  - *Synsphyronus* sp. B06
  - *Bothriembryon* sp. B01

8.6 Predicted outcome

The EPA objective for terrestrial fauna is to maintain representation, diversity, viability and ecological function at the species, population and assemblage level. This section evaluates whether the Proposal can meet this objective, having specific regard to specially protected species and other species of interest.

BIF ranges have been the subject of numerous vertebrate and SRE invertebrate fauna studies over the past decade as mining proponents and others have sought to document and understand the effects of exploration and mining activities on native wildlife.

MRL has undertaken an extensive vertebrate and SRE invertebrate fauna assessment of both the disturbance area for the Proposal and the surrounding landscape. Considerable effort has been made to complete these assessments in accordance with relevant State and Commonwealth policies and guidance, including the requirement to present information in both a local and regional context.

The vertebrate fauna assemblage of the area is therefore well understood. The SRE invertebrate fauna assemblage, though well surveyed, is less well understood. This reflects an historic understudy of invertebrates that has contributed to a lack of formal description of many species.

Representation

Overall, the fauna habitat types within the disturbance area are also well represented elsewhere in the landscape and region. Habitat connectivity is excellent due to the remote and largely undisturbed nature of the area.

The majority of the specially protected fauna species and other species of interest were recorded both within and beyond the disturbance area (i.e. they are represented in areas other than the disturbance area). Most of the vertebrate species are expected to move to adjacent areas of suitable habitat, although some impact to less mobile SRE invertebrate species will occur.

The few species that were recorded only from the disturbance area, all of which were SRE invertebrate species, occur in habitat that is well represented elsewhere in the landscape. The distribution of these species is therefore not likely to be confined to the disturbance area (**Appendix 8-B**).

The fauna assemblage is consistent with that found in other surveys of BIF ranges in semi-arid environments. There is no evidence to suggest that the fauna assemblage is unique in this regard.

Consequently, the Proposal is capable of being implemented whilst ensuring that the representation of terrestrial fauna is maintained at the species, population and assemblage levels.

Diversity

The different fauna habitat types throughout the area support a diverse vertebrate and invertebrate SRE fauna assemblage. The mixed eucalypt woodland supports the highest vertebrate species diversity, due to the greater structural complexity of the vegetation and the presence of tall trees that provide hollows, logs and habitat for arboreal species.

The rocky ridge and mallee woodland on rocky plain and footslopes supports a rich SRE invertebrate species community, due to its topographic variety that includes very suitable microhabitats such as south-facing gullies, water-runoffs, rocky breakaways, accumulations of scree and vegetation that differs from the surrounding woodland.

All fauna habitat types within the Proposal disturbance area occur extensively elsewhere. The Proposal is therefore capable of being implemented whilst maintaining the diversity of terrestrial fauna with respect to species, populations and the overall assemblage.

Viability

There is no evidence to suggest that the viability of specially protected species or other species of interest will be affected by the Proposal to the extent that their conservation status would need to be reviewed (the process through which the level of threat to survival of species is formally recognised).

From the studies undertaken to date there appear to be no identifiable, discrete populations of specially protected or other species of interest. This may be attributed to the large contiguous habitat available to all species, and the absence of habitat fragmentation that can lead to dependence on particular areas of remnant vegetation for foraging and breeding.

All species in question have large areas of habitat available to them relative to their mobility, and relatively few are found only from one habitat type i.e. most species are able to utilise more than one habitat type.

The Proposal is therefore capable of being implemented whilst maintaining the viability of fauna with regard to species, populations and the overall assemblage.

Ecological function

The extent of the disturbance area relative to the extent of habitat available to support terrestrial fauna is relatively small. From an ecological perspective, the removal of 10 % of the rocky ridge habitat type is a localised impact that is not expected to affect the functioning of the remaining 90% of this habitat type.

Within other habitat types, minor local reduction in ecological function will occur as a result of habitat clearing and fragmentation; however this reduction is neither widespread nor long-lasting and is not expected to affect the functioning of remaining habitat. In any case, ecological function will recover as vegetation regenerates in rehabilitated areas and stabilises, allowing native fauna to re-colonise from adjacent areas along the ranges and plains to the south.

The Proposal is therefore capable of being implemented whilst maintaining ecological function with respect to fauna species, populations and the overall assemblage.

For the reasons outlined above, the EPA's objective for terrestrial fauna can be met in respect of the Proposal.

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9. HYDROLOGICAL PROCESSES

9.1 EPA objective, policies and guidelines

The EPA objectives for hydrological processes and inland waters environmental quality are:

- to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected
- to maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

The policy and guidance documents referenced as part of the desktop investigations and impact assessment are provided in **Table 9-1**.

TABLE 9-1: LEGISLATION, POLICIES AND GUIDANCE CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Environmental Protection Authority (2015). Environmental Assessment Guideline (EAG 17) for Preparation of management plans under Part IV of the Environmental Protection Act 1986.	Provides a guideline on the requirements for preparation of management plans.	Used to prepare draft management plan.
Non-EPA Policy and Guidelines		
Department of Water (2013). Western Australian water in mining guideline. Water licensing delivery series, Report No. 12. Perth, Western Australia	Provides advice on water management issues that need to be considered in mine planning and the type of information that the Department of Water may require as part of the licence assessment process.	Referenced in PER **Section 9.4** in relation to licensing for groundwater abstraction

9.2 Existing environment

A detailed surface water assessment was undertaken by Soilwater Consultants (**Appendix 9-A**) to extend previous surface water risk modelling undertaken by Golder Associates (Golder Associates, 2013; 2014a; 2014b) with respect to the location of infrastructure. The detailed surface water assessment included:

- development of a Conceptual Site Model (CSM) to describe the nature of surface water movement across the disturbance area including identification of major water sources, drainage pathways and potential environmental receptors
- additional hydrological assessment that extended existing information and modelling outputs by focussing on local-scale surface water effects.

Groundwater studies have not yet been undertaken in relation to the Proposal as mining does not require dewatering, although some groundwater will be required for dust suppression purposes. However, Rockwater was commissioned to undertake a review to determine the likely groundwater levels based on data from nearby projects, local geological mapping and professional judgement (**Appendix 9-B**).

9.2.1 Regional hydrological setting

The Proposal is located at the eastern extent of the Swan-Avon River Catchment (Yilgarn Branch) within the South-West Drainage Division of WA. These regional-scale catchments drain towards a series of large, intermittent salt lakes that are generally dry through most years and fill only following periods of substantial rainfall (i.e. every 10 years or more).

There are no permanent or semi-permanent surface water bodies within 60 km of the Proposal. For this reason, it is not possible to fully characterise the baseline surface water regime with respect to water levels, water chemistry and water quality.

Surface run-off is highly ephemeral, with few defined channels forming in the landscape. Regional scale surface water flows are generally not frequent enough, and are not of sufficient volume or velocity to promote scour and channel formation.

Water infiltration rates on the BIF ranges are very high due to the gravelly nature of the soil and the majority of rainfall is absorbed by the soil profile, with only a minor proportion moving down-slope as surface run-off or entering groundwater after extremely large rainfall events.

The mine and infrastructure areas are situated on locally elevated areas within the upper reaches of a regional catchment that drains towards Lake Hamersley, some 60 km away (Figure 9-1). At J5 there is a regional-scale catchment that directs water to the east of the disturbance area.

9.2.2 Local hydrological setting

The natural direction of surface water flow is predominantly away from the mine areas and there are few opportunities for flows to traverse these areas from up-slope.

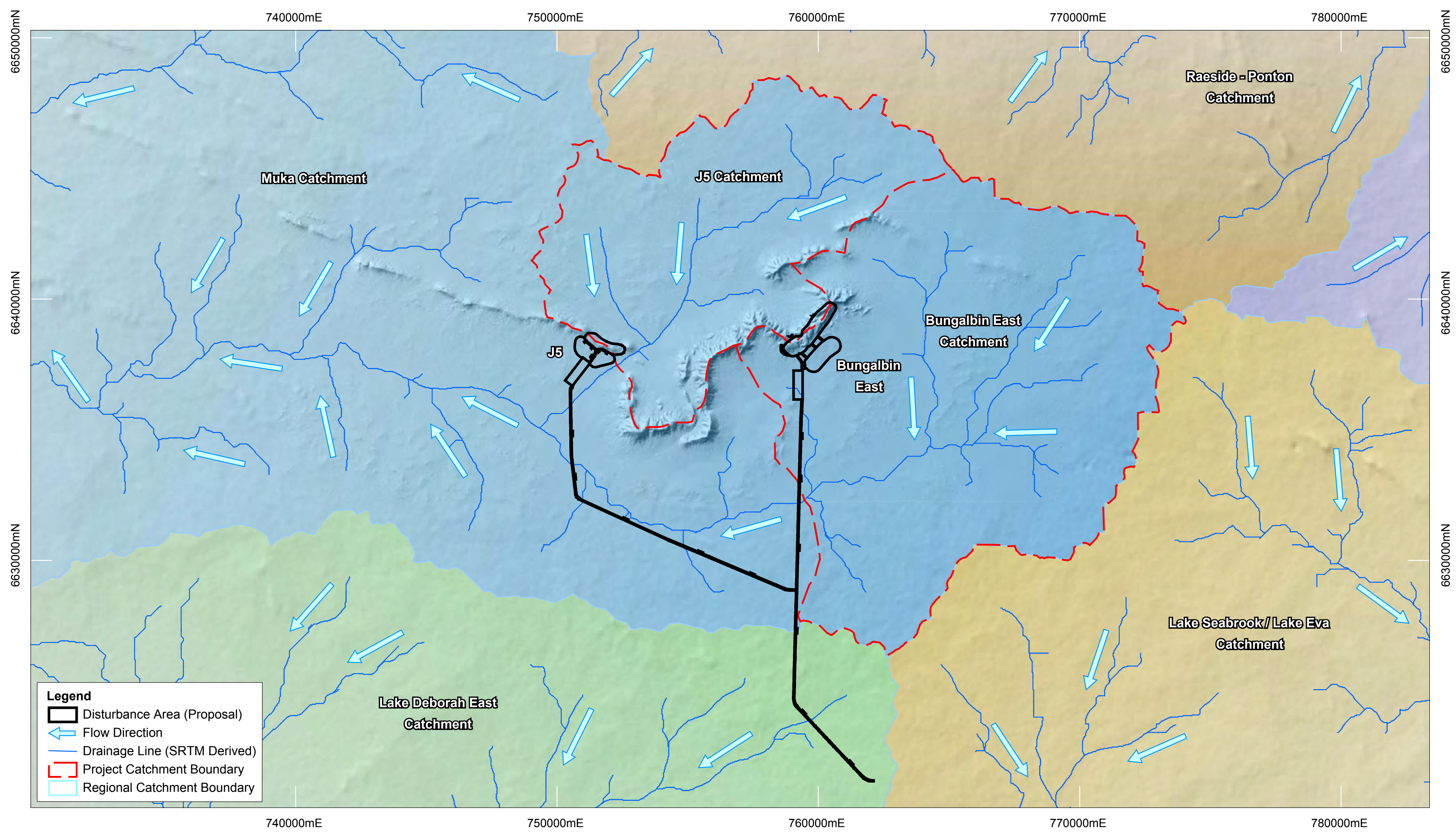
At both J5 and Bungalbin East there are no permanently flowing creeks intersecting the disturbance area. Any surface water flow collecting in drainage lines represent only local-scale runoff that is temporary in nature i.e. only occurring during large rainfall events and dissipating shortly thereafter.

There are two sub-catchments that direct water into the supporting infrastructure areas at both J5 and Bungalbin East from the north-west. The extents of these sub-catchments are 52 ha at J5 and 450 ha at Bungalbin East.

9.2.3 Hydrogeology

As with the goethite-hematite orebodies at the nearby J4 and Carina mining operations, it is expected that the orebodies at J5 and Bungalbin East will be highly broken, vuggy and locally cavernous, all of which indicates that porosity and permeability within these orebodies will be high.

Rockwater (**Appendix 9-B**) notes that groundwater level contours slope downwards to the southwest, in keeping with surface drainage towards Lake Deborah East, and indicate that the water levels at J5 and Bungalbin East are likely to be about 410 mAHD and 420 mAHD, respectively.



Notes:
Catchments and drainage from DoW and supplied by Mineral Resources (Jul 2016) as generated by Golder Associates using 1 second SRTM Derived Hydrological Digital Elevation Model (DEM-H) version 1.0 (ANZLIC Identifier: ANZCW0703014615), Source: Geoscience Australia

CAD Ref: g2378_J5_BE_PER_C09_F01_01
Date: Jul 2016 | Rev: C | A4

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CATCHMENTS AND DRAINAGE FLOW

Figure: **9-1**

A water table elevation of about 420 mAHD at the J5 deposit is indicated by records of wet samples produced during drilling of the ore body conducted by Portman Iron Ore during 2006. This is 10 m higher than indicated by the regional water level data because of a weak groundwater mound that commonly develops beneath BIF strike-ridges. The groundwater mounds are created by a relatively high rate of infiltration and recharge through the goethite – hematite rocks that form the deposits, and the low permeability of the mafic country rocks which adjoin the BIF ridges.

Although the groundwater mounds are only weakly developed, it is possible that they may become considerably larger when formed beneath very high and broad strike-ridges such as at Bungalbin East. On this basis, it is estimated that the height of the groundwater mound at Bungalbin East is probably about 30 m above the regional water level (20 m higher than at J4), which places the water level elevation there at about 450 mAHD.

In terms of water quality, the salinity of groundwater at J4 ranges from 3,600 mg/L TDS at the top of the orebody to about 25,000 mg/L TDS at deeper elevation (Rockwater Pty Ltd, 2015). The salinity of groundwater at Carina is about 25,000 mg/L TDS (Rockwater Pty Ltd, 2013).

9.3 Assessment of potential impacts

The potential impacts of the Proposal on hydrological process and water quality are:

- alteration of natural surface water flows and contamination of surface water as a result of placement, design and operation of the mine and associated infrastructure
- alteration of surface water flows may result in changes to natural erosion and deposition patterns that could increase the turbidity of surface water
- degradation and/or loss of vegetation and associated sterilisation of soil arising from the use of saline water for operational purposes such as dust suppression
- alteration of the hydrology of creeks from groundwater abstraction and reinjection if there is a connection with groundwater
- alteration of groundwater characteristics (flow, volume and quality) from groundwater abstraction, having the potential to result in:
    - degradation and/or loss of groundwater dependent ecosystems
    - displacement and/or loss of subterranean fauna (stygofauna).

9.3.1 Alteration of surface water flow and erosion/deposition patterns

There is virtually no measurable catchment area up-slope from the mine and infrastructure areas at J5 and Bungalbin East and therefore little to no surface runoff is expected to flow into these areas from higher in the catchment.

All rain that falls directly into the mine pits and the majority of rain that falls onto the WRLs is predicted to be trapped and infiltrated with little-to-no offsite run-off. The upper surface of the WRLs will be designed to capture and hold direct rainfall and allow it to infiltrate.

The regional-scale catchment that potentially directs flood flow immediately east of J5 is predicted to remain unaffected by the Proposal for the 1:100 year peak flow event. In the event of a Probable Maximum Flood (PMF), the flood water is predicted to reach the disturbance area in the vicinity of the eastern WRL, although the WRL itself remains unaffected.

The moderate-sized catchment (450 ha) that potentially directs flood flows through the supporting infrastructure area at Bungalbin East is not predicted to convey large volumes of water. The estimated 1:10 and 1:100 year peak flow rates are about 5 m^3/s and 18 m^3/s, respectively.

The minor catchment (52 ha) that potentially directs flood flows through the supporting infrastructure area at J5 is not predicted to convey large volumes of water. The estimated 1:10 and 1:100 year peak flow rates are about 2 m^3/s and 8 m^3/s, respectively.

The haul roads associated with the Proposal will not cross any permanent creek lines. However, they will intersect several wide, gently-sloping valleys that are likely to experience occasional extensive flooding in response to large rainfall events.

Previous modelling predicted that surface water flow during such events would occur as shallow (≤1 m for the 1:100 year design flood) and very wide flows (≥2,000 m in proximity to the J5 haul road) with low flow velocities (≤1 metres per second (m/s) for the 1:100 year design flood) (Golder Associates, 2014a; 2014b). PMF scenarios have not been modelled for drainage lines intersecting the haul roads as these roads are proposed to be removed following the completion of mining.

There are two major and five minor drainage lines crossing the haul roads, based on the relative size of the contributing upstream catchment area and potential volume of water to be conveyed during a flood. At the major drainage line crossing on the J5 haul road, about 2.7 km of road will be inundated during the 1:100 year annual return interval (ARI) design flood event to a maximum flow depth of about 1 m. At the major drainage line crossing on the Bungalbin East haul road, about 850 m of road will be inundated during a 1:100 year ARI design flood event to a maximum depth of about 0.85 m. Maximum flow velocities for both haul road crossings are predicted to be low (<1.0 m/s).

The Proposal will have little effect on the overall turbidity of surface water, which only occurs following periods of substantial rainfall and naturally carries high levels of suspended sediment consistent with flooding. Some alteration to patterns of erosion and deposition will occur during high rainfall events as water is conveyed around supporting infrastructure areas and WRLs.

In this regard, at J5 about half of the disturbance area comprises the range and adjoining gravelly slopes that have high resistance to erosion, with the remaining half of the disturbance occurring on more erodible plains soils. At Bungalbin East the majority (255 ha) of disturbance occurs on the range and adjoining gravelly slopes with about 35 ha of disturbance occurring on the more erodible plains soils.

There will be no surplus water discharged to the environment as mine dewatering is not required as part of the Proposal.

9.3.2 Contamination of surface water

The main sources of potential contamination associated with the Proposal are the landfills (and tyre disposal), sewage treatment systems and storage of dangerous goods such as diesel, oil and chemicals.

As previously noted there are no permanent or semi-permanent surface water bodies within 60 km of the Proposal. For this reason the Proposal is not predicted to have a measurable effect on surface water quality.

9.3.3 Degradation and/or loss of vegetation

Degradation and/or loss of vegetation and associated sterilisation of soil are potential indirect impacts arising from the application of saline water on unsealed roads and other bare surfaces for the purpose of dust suppression. Such impacts are secondary to the initial direct impact from clearing, but can increase the overall extent of the disturbance area if not managed appropriately.

9.3.4 Groundwater abstraction

The standing water level within the J5 and Bungalbin East ore bodies is inferred to be up to 420mAHD and 450 mAHD respectively. Mining will not occur below the water table so dewatering at either deposit will not be required. However, groundwater will be abstracted from bores in proximity to each ore body to supply water for operational purposes such as dust suppression.

The estimated overall water requirement for the construction and operations phases is 1,725 kL per day (629,625 kL per annum). To meet this requirement, an average of 785 kL per day (286,525 kL per annum) will be abstracted from local bores at the mines. The remaining water requirements for existing MRL infrastructure will be covered by existing approved water sources as detailed in **Table 9-2**.

TABLE 9-2: SOURCES OF WATER FOR J5 AND BUNGALBIN EAST

Water source	Spring-Summer (kL/day)	Autumn-Winter (kL/day)	Annual Average (kL/day)
From Carina/J4 Pits	1,220	660	940
J5 Local Bore	400	240	320
Bungalbin East Local Bore	580	350	465
Grand Total	2,200	1,250	1,725

In terms of potential impacts on subterranean fauna (stygofauna) arising from groundwater abstraction, there is predicted to be no measurable effect as: (a) stygofauna are unlikely to occur due to groundwater salinity; and (b) the volume of water proposed to be abstracted is relatively low in the absence of mine dewatering (**Appendix 7-A**).

As there are no groundwater dependent ecosystems in proximity to the Proposal there can be no degradation and/or loss of such ecosystems.

As there are no permanent or semi-permanent surface water bodies, including creeks, within 60km of the Proposal, there can be no measurable effect on the hydrology of creeks from groundwater abstraction.

9.4 Proposed environmental management

The effects of the Proposal on hydrological processes and water quality can be minimised through implementation of a draft Surface Water Management Plan (**Appendix 9-C**) in conjunction with MRL's EMS for the Proposal, which includes plans and procedures relevant the management of water (Table 9-3).

In respect of alteration of surface water flow and erosion/deposition patterns, specific surface water management controls will be implemented as outlined in MRL-EN-PLN-0002 and supplemented by relevant controls outlined in MRL-EN-PRO-0003. These controls include:

- ensuring diversions/drains maintain continuity of surface water flow through the catchment by returning diverted flows to natural drainage pathway
- design and construct haul roads with low-pass floodways and other appropriate cross-road drainage and turnouts

- capture and treat all stormwater on-site prior to release off-site through installation of:
    - containment bunds around supporting infrastructure areas and sediment control bunds along the southern edges of the WRLs to ensure stormwater is retained within disturbed areas
    - sediment traps at low points along the perimeter of bunded areas to reduce sediment concentration in run-off water prior to releasing water off-site
- removal of drains, bunds and sediment traps and re-establish natural drainage at site closure.

TABLE 9-3: MANAGEMENT OF SURFACE WATER – MRL PLANS AND PROCEDURES

Doc. No	Title	Description
MRL-EN-POL-0001	Environment and Community	Company policy in relation to the environment and communities.
MRL-EN-PLN-0001	Environmental Management Plan	Outlines the systematic approach to environmental management.
MRL-EN-PLN-0003	Rehabilitation and Mine Closure Plan	Outlines the approach, objectives and completion criteria for rehabilitation and mine closure, including drainage.
MRL-EN-PLN-0002	Surface Water Management Plan	Outlines the approach for managing surface water run-off in relation to the Proposal, particularly from cleared areas with erosive soils.
MRL-EN-PRO-0002	Hydrocarbon and Chemicals	Describes the required management of hydrocarbons and chemicals to prevent contamination of the surrounding environment, particularly soil and water resources.
MRL-EN-PRO-0003	Surface Water	Outlines a framework for managing surface water to prevent adverse impacts from contamination, discharges and disturbance to natural drainage flows.
MRL-EN-PRO-0011	Waste Management	Provides a framework and controls for managing waste in landfills, tyre storage and disposal, controlled waste and recycling.
MRL-EN-PRO-0012	Dust Management	Describes the general requirement to suppress dust generation from mining and processing activities.
MRL-EN-PRO-0013	Groundwater management	Provides a framework for management of groundwater to prevent unauthorised use or adverse impacts.
MRL-OHM-PRO-0007	Incident Reporting	Outlines MRL's requirements in regard to incident classification and required timeframes for the reporting of incidents by impact type and actual and potential consequence level.

In respect of potential contamination of surface water, routine surface water controls will be implemented as outlined in MRL-EN-PRO-0002. These controls include:

- equipment servicing to occur in workshops wherever possible
- diversion of runoff from workshop areas and other areas likely to contain hydrocarbons to sumps and oil traps to remove contaminants prior to disposal off-site
- storage and transportation of all chemicals stored or transported to the mining areas in accordance with Dangerous Goods Regulations
- diversion of stormwater away from landfill trenches and retention of contaminated stormwater on-site.

In respect of groundwater abstraction and degradation and/or loss of vegetation arising from the application of saline water for dust suppression, routine groundwater and dust management controls will be implemented as outlined in MRL-EN-PRO-0003 and MRL-EN-PRO-0012, respectively. These controls include:

- daily inspection of saline water pipelines and turkey nests
- fitting of automatic water shut-off valves and float sensors in turkey nest dams
- maintenance of 300 mm freeboard within turkey nest dams
- installation of secondary containment around pipelines to mitigate accidental discharge to the environment from pipeline failure, with pipelines and turkey nests to be inspected daily for leaks and/or spillage
- turkey nest dams will be lined with HDPE membrane to prevent seepage
- water cart operators must be present and continuously supervising refilling to prevent spillage due to overfilling
- overspray of saline water for mine road dust suppression will be prevented by spray bar and nozzle design and management of spray pressure.

Any groundwater abstraction will only occur under licence issued under the *Rights in Water and Irrigation Act 1914* by the Department of Water.

9.5 Residual impacts

The residual impacts from the Proposal on hydrological process and inland waters environmental quality once all efforts to avoid, minimise and rehabilitate the proposed extent of disturbance have been considered are:

- Removal of a small portion of the upper reaches of a regional catchment as a result of the excavation of three mine pits. The mine pit at J5 and the northern mine pit at Bungalbin East will remain as pit voids, while the southern mine pit at Bungalbin East will be partially backfilled to create a predominantly flat surface with internal drainage i.e. it will not contribute to surface water flow down-slope.
- Alteration of a small portion of the upper reaches of a regional catchment as a result of the construction of three WRLs. These WRLs will alter the local topography and therefore surface water drainage in the immediate vicinity of the WRLs although this alteration will have little effect at the catchment scale.

9.6 Predicted outcome

The EPA objectives for hydrological processes and inland waters environmental quality are to:

- maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected
- maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

The hydrological regimes of groundwater and surface water are understood as a result of regional and local assessments of surface water, including hydrological modelling, as well as hydrogeological modelling of fractured rock aquifers undertaken at nearby mining operations i.e. Carina and J4.

The Proposal occurs in a semi-arid environment where plants and animals have adapted to infrequent rainfall events and relatively low annual rainfall. As a consequence there are no permanent or semi-permanent features holding surface water in the landscape that are relied upon by either plants or animals for survival. There are no surface expressions of groundwater, no groundwater dependent ecosystems, or any sheet-flow dependent vegetation communities.

Groundwater occurs at considerable depth below the surface and is not accessible unless pumped to the surface. There are no groundwater bores in the vicinity of the Proposal, with the exception of the J4 mine to the west and the Carina mine to the south-east. Potential future uses or demand for groundwater appear limited as there are few other land uses in the area that require water e.g. pastoralism.

The Proposal can therefore be implemented whilst maintaining the hydrological regimes of groundwater and surface water such that existing and potential uses, including ecosystems maintenance, are protected.

The Proposal is not expected to affect the quality of groundwater as there is no measurable relationship between the infrequent occurrence of surface water and the extent of infiltration to groundwater. It is understood that significant quantities of water are stored within the soil profile prior to potential transmission to groundwater.

Sediment quality may be affected in the absence of appropriate management of various aspects of the proposal including stormwater drainage, waste disposal and storage/use of chemicals and hydrocarbons. Overall, however, these effects on sediment quality will not be significant and therefore the Proposal can be implemented whilst maintaining the quality of groundwater and surface water, sediment and biota so that the environmental values are protected.

For the reasons outlined above the Proposal can meet the EPA's objective for hydrological processes and inland waters environmental quality in respect of the Proposal.

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10. AMENITY

10.1 EPA objective and policy

The EPA objective for amenity is to:

- ensure that impacts to amenity are reduced to as low as reasonably practicable

The policy and guidance documents referenced as part of the field investigations and impact assessment are provided in **Table 10-1**.

TABLE 10-1: LEGISLATION, POLICIES AND GUIDANCE CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key Aspects of Policy	Application
EPA legislation		
Environmental Protection (Noise) Regulations 1997	Provide criteria as to acceptable limits for noise.	The regulations apply to "sensitive premises", of which none occur in the vicinity of the Proposal. Nonetheless, the relevant noise criteria have been applied for the purpose of assessing the impact of the Proposal on amenity in relation to noise emissions. Refer to **Appendix 10-A** for further detail.
EPA Policy and Guidelines		
EPA (2008) EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development. Perth, Western Australia.	Provides information and advice on a range of environmental issues and their protection and management, including visual amenity. Key principles that the EPA takes into account when visual amenity is examined during the EIA process is the retention of natural landscape character in areas of high conservation significance and the visual harmony of new development with the natural surrounds.	The assessment of the potential impacts to visual amenity from implementation of the Proposal is detailed in **Section 10.3.1**. Further detail is provided in **Appendix 10-B**.
EPA (2014) Environmental Assessment Guideline 13 for Consideration of Environmental Impacts from Noise. Perth, Western Australia.	Assists proponents to determine whether a proposal should be referred to the EPA on impacts from noise alone, and whether a detailed noise assessment of potential impacts may be	The assessment of potential impacts to amenity from noise emissions arising from implementation of the Proposal is detailed in **Section 10.3.3**. Further detail is provided in

Legislation, Policy and Guidelines	Key Aspects of Policy	Application
	required. It requires proponents to achieve compliance with requirements of the *Environmental Protection (Noise) Regulations 1997* or *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* where applicable, and other accepted standards.	**Appendix 10-A**. The noise assessment addresses the noise criteria provided in the regulations, although there are no sensitive premises (as defined in the regulations) in the vicinity of the Proposal.
EPA (2007) Report 1256: Advice on areas of the highest conservation value in the proposed extensions to Mount Manning Nature Reserve. Advice of the EPA to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986. Perth, Western Australia.	The advice primarily concerns Mt Manning Range Nature Reserve and proposed extensions, also known as the Yilgarn Conservation Reserves. This advice identifies areas that should be protected from mining and the use of environmental offsets. The advice makes numerous reserve recommendations including that part of the MMHARCP be reserved as an A Class Nature Reserve for protections of, amongst other things, exceptional landforms. This recommendation has not been adopted by Government. The key factors listed in the advice include "substantial landforms with significant visual amenity."	The PER considers the impact of the Proposal on landforms (**Section 6**) and visual amenity (this section). Report 1256 does not provide specific guidance on the assessment of impacts to amenity.
EPA (2015a) Environmental Protection Bulletin No. 24: Greenhouse gas emissions and consideration of projected climate change impacts in the EIA process. Perth, Western Australia.	Discusses the circumstances under which the EPA will assess greenhouse gas emissions associated with development proposals. In addition to regulating greenhouse gas emissions the EPA may, on a case by case basis, take into account the projected impacts of climate change in its assessment of proposals.	Not applicable to the assessment of amenity impacts. It is noted that the Air Quality Assessment prepared by Pacific Environment included analysis of PM_{10} and $PM_{2.5}$ concentrations for the Proposal, which are indicators usually associated with greenhouse gas emissions and human health impacts (see **Appendix 10-D**). Greenhouse gases and climate change, however, are not

Legislation, Policy and Guidelines	Key Aspects of Policy	Application
		discussed within the Amenity chapter of this PER.
EPA (2015b) Environmental Assessment Guideline (EAG) 17 for Preparation of Management Plans under *Part IV* of the *Environmental Protection Act 1986*. Perth, Western Australia.	Provides guidance to proponents on the content of management plans under *Part IV* of the EP Act (Condition EMPs). Provides proponents with a clearer understanding of their obligations in implementing management plans. Also aims to improve the readability of management plans for the public.	The Amenity Management Plan (AMP) prepared as part of MRL's Environmental Management System for the Proposal applied the guidance outlined in EAG 17. The AMP is provided in **Appendix 10-D**.
EPA (2015c) Environmental Protection Bulletin No. 23: Guidance on the EPA Landforms Factor. Perth, Western Australia.	Provides high level guidance for consideration by proponents on the EPA's objective for the Landforms factor.	The impact on landform is considered in the context of visual amenity i.e. the visual impact of the Proposal on the landform.
DMP and EPA (2014) Guidelines for Preparing Mine Closure Plans.	Aims to ensure that a planning process is in place so that the mine can be closed, decommissioned and rehabilitated to meet the DMP and EPA's objectives for rehabilitation and closure.	Mine rehabilitation and decommissioning is addressed in **Section 13** with further detail provided in the Rehabilitation and Mine Closure Plan contained in **Appendix 12-D**.
Non-EPA Policy and Guidelines		
Department of Conservation and Land Management [CALM] (1989) Policy Statement No. 34: Visual Resources Management on Lands and Waters Managed by CALM. Perth, Western Australia.	Provides policy measures for visual resource management to ensure all uses and activities are planned and implemented so as to complement rather than detract from the inherent visual qualities of the environments in which they occur. It seeks to ensure that all mining activities including exploration and rehabilitation phases are planned so as to minimise the impact on existing landscape values.	Impacts to landscape values have been minimised as part of the mine design/planning process. An assessment of the visual impact of the Proposal has been undertaken by Bioscope Environmental (**Appendix 10-B**) – refer also to **Section 10.3** for further details. A Rehabilitation and Mine Closure Plan has also been prepared that addresses the rehabilitation phase of the Proposal. Refer to **Section 12** and **Appendix 12-D** for further details.

Legislation, Policy and Guidelines	Key Aspects of Policy	Application
Department of Conservation and Land Management, Department of Planning and Urban Development and Department of Environmental Protection (1994) Reading the Remote: Landscape Characters of Western Australia. Department of Conservation and Land Management, Como.	Provides a range of descriptors that can be used to define visual landscape character including form, line, colour, texture and scale.	Relevant descriptors have been used by Bioscope Environmental to define visual landscape character. Refer to **Appendix 10-B** for further detail.
Department of Environment and Conservation (2011). A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities. Perth, Western Australia.	Provides guidance on preparing a plan for the management of dust and associated contaminants arising from activities such as land clearing for development, mining and quarrying.	The management of potential impacts to air quality from dust emissions is discussed in **Section 10.3.4**.
Western Australian Planning Commission and Department for Planning and Infrastructure (2007) Visual Landscape Planning in Western Australia. A Manual for Evaluation, Assessment, Siting and Design. Perth, Western Australia.	Manual produced by the WAPC and DPI with input from DPaW, Main Roads WA and other agencies that manage landscapes and landforms in WA. The manual provides advice to state agencies, local governments, developers and the community on techniques for incorporating visual landscape planning into the planning system.	This manual has been applied as part of the assessment of the visual impact of the Proposal by Bioscope Environmental (**Appendix 10-B**). The assessment of the potential impacts on visual amenity of the Proposal is detailed in **Section 10.3.1** with further detail provided in **Appendix 10-B**.
Western Australian Planning Commission (2009) State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning. Perth, Western Australia	Promotes a system in which sustainable land use and transport are mutually compatible.	Not applicable due to the remote location of the Proposal and the absence of urban development.
Commonwealth Policy and Guidelines		
NEPC (2003). National Environmental Protection (Ambient Air Quality) Measure. Canberra, ACT.	Provides a framework and guidelines about standards and methods for monitoring ambient air quality.	The assessment of potential impacts to air quality from implementation of the Proposal is detailed in **Section 10.3.4**

Legislation, Policy and Guidelines	Key Aspects of Policy	Application
		with further detail provided in **Appendix 10-D**. The assessment considers the guideline threshold values for air quality indicators such as Total Suspended Particulates, PM_{10} and $PM_{2.5}$.

This PER has been prepared to be consistent with all policy and guidance documents referenced in **Table 10-1**.

10.2 Existing environment

MRL has undertaken a combination of desktop and field-based studies for the purpose of characterising the land use and amenity values of the MMHARCP and predicting the impact of the Proposal on amenity. The field-based studies include assessments of visual amenity, noise and air quality.

The amenity of the MMHARCP has been assessed with regard to several key elements that together comprise amenity, namely:

- visitor access and use
- visual landscape
- noise
- air quality
- light.

The existing environment, potential impacts, proposed management and predicted outcomes are discussed further below in the context of these key elements.

10.2.1 Visitor access and use

The MMHARCP was gazetted in 2005 and is vested in the Conservation and Parks Commission (CPC). The CPC was established in May 2016 following changes to the CALM Act in late 2015, and replaces the Conservation Commission of WA and the Marine Parks and Reserves Authority to become the vesting body for conservation lands, forest and marine reserves.

The CPC also provides advice to the WA Government on conservation matters. The CPC has a formal planning role for the management of regional parks, enabling the DPaW to manage these ecologically significant areas in cooperation with landowners (Department of Parks and Wildlife, 2016).

The MMHARCP is managed by the DPaW for the purpose of "recreation by members of the public" and "proper maintenance and restoration of the nature environment, the protection of indigenous flora and fauna, and the preservation of any feature of archaeological, historical or scientific interest".

The MMHARCP is a relatively undisturbed natural environment that offers visitors the opportunity to experience a remote, outback experience within a varied landscape that contains diverse native flora and fauna (Department of Environment and Conservation, 2008). As such it is currently used for recreation and tourism, including four-wheel driving, camping, hiking and nature appreciation (Department of Environment and Conservation, 2008).

Access to the MMHARCP is via unsealed tracks from the south (Koolyanobbing), west (Mt Jackson/Marda), east (Mt Dimer/Mt Walton) and north-east (Menzies). Visitors accessing the MMHARCP from Mt Jackson and Koolyanobbing must cross mine haul roads associated with the Mt Jackson (J1) (Marda Track junction) and J4 mines (Koolyanobbing Track junction), respectively.

A number of access tracks within the MMHARCP are historical or current mining exploration tracks and are not necessarily maintained, with some tracks only accessible by walking from vehicles (to access higher elevations within the Park).

A more in-depth understanding of the way in which visitors access and use the MMHARCP has been informed by stakeholder consultation undertaken by MRL, including face-to-face meetings and correspondence with the OEPA and DPaW, and telephone interviews with the following groups:

- Three NGOs (Helena and Aurora Ranges Advocates Inc [HARA], Wilderness Society and Wildflower Society).
- Four recreational groups (Adventure 4WD, WA 4WD Association, Eastern Goldfields 4WD Club and All Tracks 4WD Club).
- Three community members known to use the Helena and Aurora Ranges (HAR) for recreational purposes (comprising a Perth-based individual and two Southern Cross residents).
- A commercial tour operator (Coates Wildlife Tours).

Telephone interviews were guided by a structured visitor use survey that included questions on the frequency and purpose of park visitation, duration of stay and activities undertaken. In essence, the focus of the survey was on how visitors access the MMHARCP, where they went to view the landscape, and what landscape features they valued. Most interviews also included substantial unstructured conversations that covered many aspects not included in the survey questionnaire.

Key findings from MRL's stakeholder consultation program in relation to visitor access and use include:

- The MMHARCP is accessible for day use or overnight camping from locations such as Kalgoorlie, Southern Cross and Perth. Visitor types vary from private individuals and families to seasonal tour groups on day trips to the Helena-Aurora Range and wider Mount Manning area, or camping for one or more nights in the MMHARCP.
- The Koolyanobbing Track is the main access route. In general, stakeholders could identify Koolyanobbing Track route by name, but there was very little name recognition for the other tracks other than by professional tour guides and environmental groups (NGOs).
- Key activities undertaken in the MMHARCP are four-wheel driving, camping, bushwalking/hiking and nature appreciation in the form of sightseeing, wildflower viewing and bird/wildlife viewing; however additional activities undertaken in the Park also include photography, picnicking/barbequing, and relaxing.
- Nearly all of those surveyed participated in most of the above activities, and around half of the four-wheel drive enthusiasts mentioned the "tread lightly" philosophy. It was noted that visiting Aboriginal/cultural sites is not a popular activity in the Park, with the reasons for this including lack of interest and cultural sensitivity (i.e. not wishing to visit these places in the absence of an appropriate guide). It was

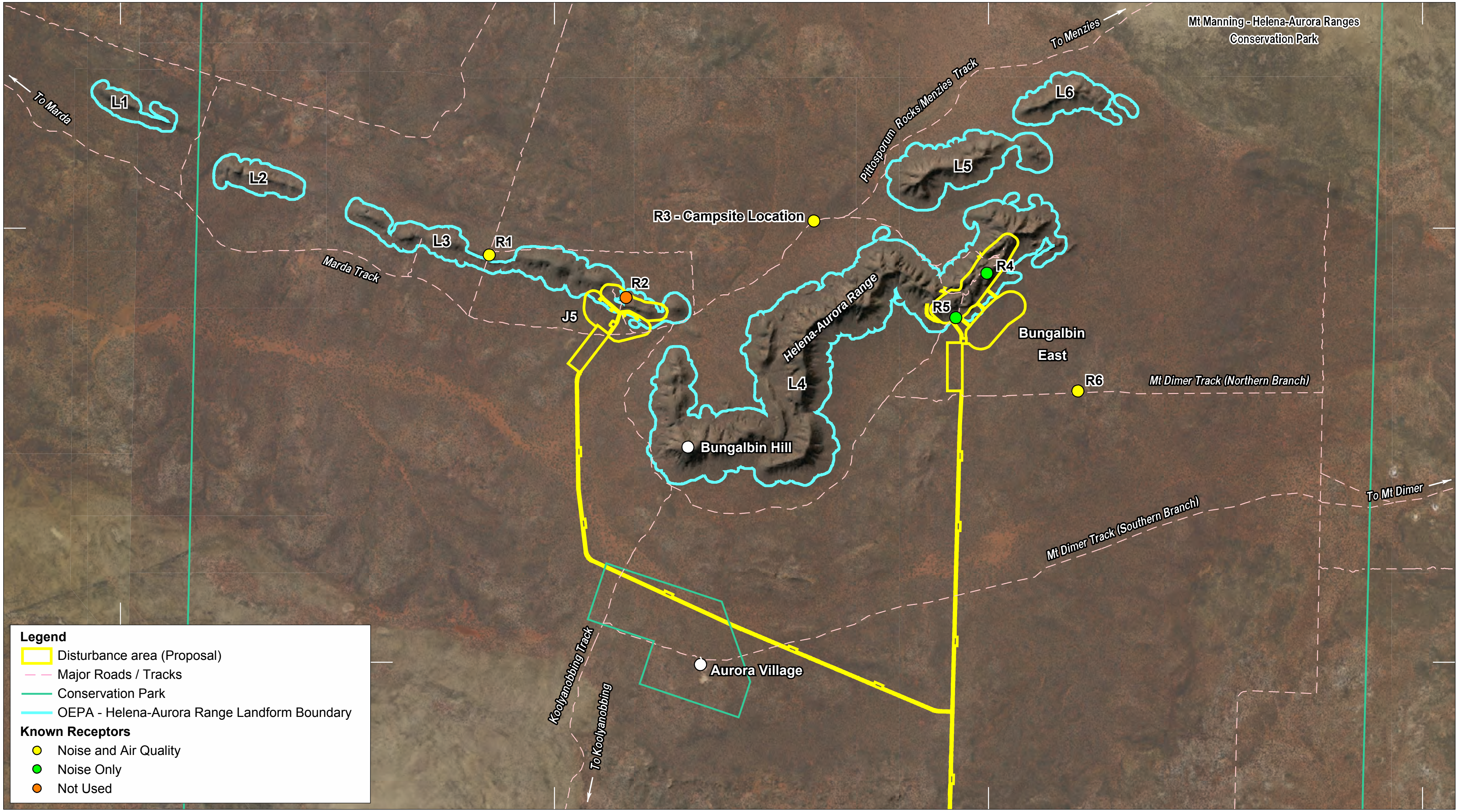
identified that high-energy activities such as rock climbing, abseiling and cycling were not common or popular activities within the MMHARCP.

- The majority of those consulted generally stay on the tracks within the MMHARCP, driving as far as possible, then walking to elevated vantage points such as the Bungalbin East former campsite, the J5 campsite and Bungalbin Hill.
- Most of those consulted by MRL could not name the high points of the HAR, but it was evident that a key objective of these visitors is to get up as high as possible into the range and observe panoramic views from accessible locations. These include the former Bungalbin East campsite, J5 lookout and Bungalbin Hill, but it is recognised that other high points are readily accessible. In addition to the views, high points are favoured for provision of mobile telephone connections.
- Tour groups, conservation groups and recreational 4WD groups are known to visit the MMHARCP. The number of visitors on tour groups to the MMHARCP is not well defined in publicly-available information, but it is understood that one tour company can accommodate approximately 15-20 people per tour.
- Visitation to the Park generally occurs during the cooler months of the year due to the lack of water sources, remoteness of the area and higher temperatures during summer months. Wetter periods are also likely to be avoided due to a higher risk of tracks become waterlogged and impassable to four wheel drives (DEC, 2008). This is supported by the traffic data, with consistently higher traffic volumes between April and October than at other times of the year.
- Despite being readily accessible from Perth, Kalgoorlie and Southern Cross, annual visitor numbers to the Park are low, and there are no visitor facilities typically associated with recreational use of reserves such as toilets and camp grounds. Data from traffic counters deployed in two separate locations by DPaW during 2013-2015 indicates that an average of 340 vehicles access the MMHARCP annually, corresponding to an annual average visitation of 1,362 persons.
- The serenity of the area and the fact that it does not have high visitation rates are drawcards for most of the stakeholders consulted, as is the relative ease of access to the MMHARCP from Perth.

Whilst there are no ‘sensitive receptors’ as defined by the *Environmental Protection (Noise) Regulations 1997* in the MMHARCP in the form of permanent human occupation, there are areas that are clearly important for human use. **Figure 10-1** denotes locations used within the Park (R1 through R6) that have been identified as important sites for visitors to the Park and includes the former campsite at Bungalbin East (R4) where camping is now prohibited, and a recently designated camping area on the Pittosporum Rocks/Menzies Track north of the HAR (R3). This area (R3) has long been used informally and has recently been sign-posted for such use.

Informal camping is not confined to the locations shown in **Figure 10-1**, as evidenced by fire pits (R1, R2 and R5) elsewhere on the HAR and the surrounding plains, including the occasional use of exploration drill pads at both J5 and Bungalbin East for such purposes. There is more than one route to the campsite on the northern side of the HAR (R3), although the track across the range in the vicinity of Bungalbin East has become impassable in recent times. Camping trips are organised by a range of organisations including the Wilderness Society (The Wilderness Society, n.d.).

MRL’s Aurora Village is located directly south of the Proposal but is considered a non-permanent residence as it is managed for the nearby J4 mining operation.



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Imagery: Landgate (2012)

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VISITOR ACCESS AND USE

Figure: **10-1**

10.2.2 Visual landscape

An assessment of the visual impact of the Proposal was undertaken by Bioscope Environmental Consulting (**Appendix 10-B**). The assessment comprised a desktop evaluation and site visits on three occasions (July 2015, February 2016 and June 2016) with field data and photographs recorded at 52 sites.

Data from the desktop analysis and field assessment were analysed to assess the significance of potential direct and indirect impacts to visual amenity in terms of their likely extent, severity and duration (**Appendix 10-B**). Photographic montages and modelling of visual conditions before, during and after mining were prepared by Bioscope Environmental (Appendix 10-B) for 11 study sites to facilitate assessment of the visual impacts potentially associated with the Proposal. These sites were selected in consultation with, and agreed to by, the OEPA and the DPaW.

A peer review was commissioned to provide assurance that the VIA has addressed the requirements outlined in the ESD (Environmental Protection Authority, 2015a) and relevant guidance such as the WAPC visual landscape planning manual. The review was conducted by Sonya Bateman of Ecoscape Pty Ltd, who concluded that some additional work would be of benefit to fully address the WAPC (2007) methodology (**Appendix 10-C**). The VIA was revised where required to address relevant comments and a close out report has been provided.

Landscape character type

Landscape character types are distinct types of landscape that share similar combinations of geology, topography, land cover and historical land use (**Appendix 6-A**). The MMHARCP offers the potential for visitors to experience the varied landscape and landforms including BIF ranges, sandplains and woodlands (DEC 2008). The Proposal occurs within the Kalgoorlie Plain Landscape Character Type (Department of Conservation and Land Management, 1994).

The region is characterised by an expansive, gently inclined landform which appears to be level in many areas, but is interrupted by conspicuous hills and low ranges such as the HAR. From a distance, these features appear as dominant focal points, but have a more commanding presence when viewed in close proximity. The landscape is dissected by scattered chains of salt lakes that can become linked after heavy rains (Department of Conservation and Land Management, 1994). The HAR and Koolyanobbing Range are the most prominent features in the area mapped by Newbey (1985), with the HAR being the most prominent feature in the Landform Assessment Unit (LAU) (**Appendix 6-A**).

The region's vegetation is considered by CALM (1994) to be one of the intrinsic visual components of this landscape. The vegetation of the area comprises a mosaic of woodland, mallee, grassland, shrubland and unvegetated areas (Watson, et al., 2008) and forms part of an extensive area known as the Great Western Woodland (GWW).

Perhaps the most visually dominant vegetation type is the tall eucalypt woodlands which tend to enclose and channel long views. Views which penetrate deeply into the woodlands are generally obscured, in part or in full, by the upper canopy while mid-section views are interrupted by slender tree trunks (CALM et al., 1994). The lower storey within woodland areas is variable in colour and texture, and can include the softer greys of saltbush. The woodlands are interspersed with patches of low bushy heath that allow broader views over the gently undulating landscape (CALM et al., 1994).

In Spring, assuming that there have been good winter rains, the large diversity of flora species for which the Great Western Woodlands is known (Watson et al., 2008) becomes evident in a profusion of vividly-coloured wildflowers that appear among the green-grey health (CALM, 1994) or as colourful vistas (Watson et al., 2008).

Landscape character units

Detailed mapping of local landscape characteristics and the regional landform mapping by Newbey (1985) were utilised in the VIA to identify four LCUs within the LAU. These are:

- Western Range LCU
- Central and Eastern Ranges LCU
- Plains LCU
- Drainage Lines LCU

These LCUs are mapped on **Figure 10-2** and described in the VIA (**Appendix 10-B**).

In summary, the Plains LCU (as mapped) covers the largest area of the LAU at 25,514.79 ha. This unit is broad, open and relatively flat, and occupies a lower position in the landscape. The terrain is gently undulating and includes a number of low ridges and other elevated features, but none of these are as visually dominant in the LAU as the Western Range LCU and the Central and Eastern Ranges LCU. The LCU provides open views where lower shrublands occur, but views become partially or completely enclosed where the vegetation is higher and/or denser.

The Western Range LCU and the Central and Eastern Ranges LCU are both described as being elevated with generally broad, open views that become partially enclose by woodlands and taller shrublands (see **Appendix 10-B**). However, the Western Range LCU is visually different to the Central and Eastern Ranges LCU as it has a generally lower elevation and has hills that are generally more rounded than those in the Central and Eastern Ranges). The Western Range LCU (as mapped) covers the smallest area of the LAU at 727.66 ha.

The Drainage Lines LCU covers an area about three times the size of the Western Range LCU at 2,120.48 ha, but smaller than the Central and Eastern Ranges LCU (2,723.57). Its presence low in the landscape is similar to that of the Plains LCU, though it can be distinguished visually from elevated areas based on changes in vegetation patterns. Where vegetation is taller and/or denser, views become more enclosed and can be obscured.

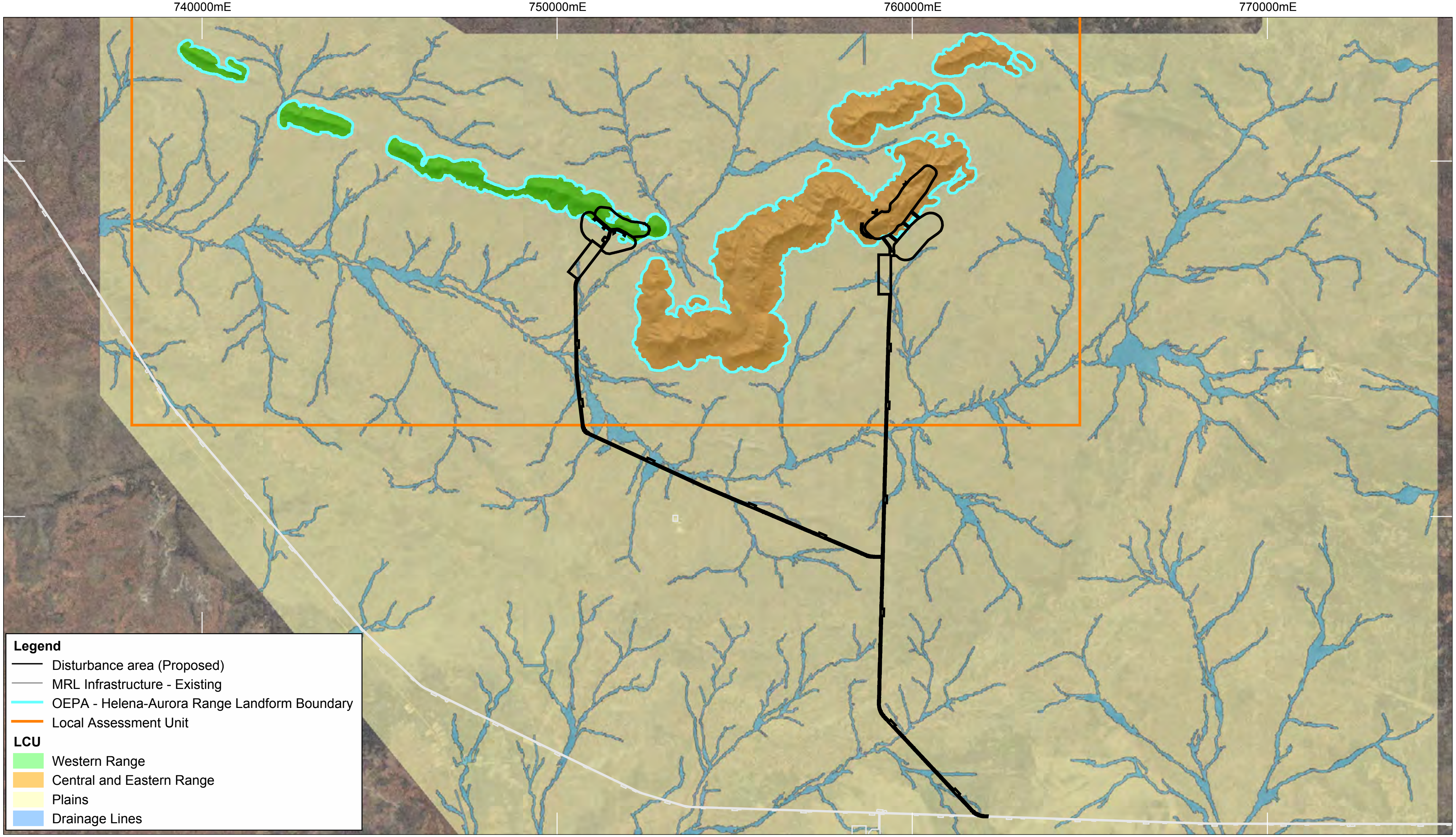
Visual receptors and viewing points

For the purposes of this assessment, key visual receptors comprise visitors travelling through the area without stopping as well as those who make day trips or stay for longer periods.

Information on known vantage points in surrounding areas, travel routes and areas of important human use (see **Figure 10-1**) was analysed as part of understanding the view experience of visitors to the MMHARCP. Locations within the Park have been identified as important sites for visitors include fire pit locations (R1, R2, R5 and R6) and campsites (R3 and R4) shown on **Figure 10-1**.

The assessment describes the view experiences from view points and travel routes selected in consultation with the OEPA and the DPaW: These were:

- J5 and Bungalbin East
- the four main access tracks to the MMHARCP (see below)
- the Mt Manning Track
- Two regional vantage points to view the HAR – Mt Manning and Mt Dimer.



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LANDSCAPE CHARACTER UNITS

Figure:
10-2

Four unsealed tracks provide access to the MMHARCP and each track provides a view experience for visitors that has been discussed in detail in the VIA. The track locations are:

- the Koolyanobbing Track, which provides access from the south
- the Marda Track, which provides access from the west leading from the Bullfinch-Evanston Road
- the Gus Luck/Mt Dimer Track, which provides access from the east
- the Pittosporum Rocks/Menzies Track, which provides access from the northeast.

Visual landscape character

The HAR landscape comprises distinctive rock formations and rugged landforms that rise above the undulating plains. The visual landscape character of the HAR, as assessed in the VIA (**Appendix 10-B**) can be described as:

- As a result of the HAR's geological setting and lithology, the HAR is characterised by fractured rock surfaces, fissures and depressions, and exhibits wide variation in both slope and aspect.
- The western portion of the HAR is lower than the eastern portions and characterised by more gently rounded hills. Rocky outcrops and small caves are present in areas throughout the western portion of the HAR. In addition, a small monolith is present at J5.
- The central portion of the HAR comprises the largest continual area of the range and includes Bungalbin Hill (at the western end) and Bungalbin East (at the eastern end) together with two smaller disjunct hills to the northeast. This portion has generally higher elevation than the western portion of the range.
- Rocky outcrops and caves are common within the central and eastern portions of the HAR, perhaps more so on the southern side of the ranges. Small cliff faces are also present in some areas.

In terms of visual landscape, the scenic qualities of the MMHARCP emanate primarily from its distinctive rock formations, rugged ridgelines and contrasting vegetation patterns. The key scenic qualities of the HAR and surrounds were identified in consultation with key stakeholders as part of the VIA (**Appendix 10-B**).

The visual quality of the HAR and surrounding plains classified by Bioscope Environmental (**Appendix 10-B**) identified the landforms with 'high scenic quality' as:

- Bungalbin Hill.
- The central portion and eastern portions of the HAR where views of the rugged ridgelines are evident above or through vegetation.
- Assemblages of small caves, particularly in the eastern part of the central portion of the HAR.

Landforms identified by Bioscope Environmental (**Appendix 6-A**) as having 'moderate scenic quality' are a small "monolith" at J5; cliff faces, and the western portion of the HAR where views of the range are partially obscured by vegetation. Expanses of similar landforms such as foothills, which are often visually obscured by denser vegetation and which provide few landmarks, were identified as having a 'low scenic quality' (**Appendix 6-A**).

The HAR's high level of visibility and the complexity of the landform and its habitats means that it contributes significantly to the "sense of place" associated with the MMHARCP (**Appendix 6-A**).

10.2.3 Noise

An assessment of environmental noise was undertaken by Herring Storer Acoustics (**Appendix 10-A**) that included measurement of baseline noise conditions and prediction of noise emissions arising from the Proposal.

The baseline noise environment for the Proposal has been characterised in part by the monitoring of background noise prior to any mining or construction activities commencing.

Background noise measurements are representative of the natural background noise of the MMHARCP (**Appendix 10-A**). The range of noise levels measured during the two week measurement period is displayed in **Table 10-2**.

TABLE 10-2: BASELINE NOISE LEVELS

Parameter	Noise level dB(A)
Minimum noise level	23.4
Minimum L_{A90}	23.5
Minimum L_{A10}	24.2
Median minimum noise level	30.6
Median L_{A90}	33.4
Median L_{A10}	43.4
Minimum Peak noise level	53
Median Peak	88
Maximum Peak	123

Overall, despite evidence of variability of background noise, the MMHARCP is a relatively quiet environment with background noise consisting of wind, rain and bird calls.

Other sources of noise and vibration that may be experienced depending on the receptor's location and weather conditions include existing haul road traffic (trucks), public access track traffic (light vehicles) and perhaps haulage trucks on internal mine access roads. Localised noise will also occur at campsites when utilised by visitors to the MMHARCP (see **Figure 10-1** for receptor locations within the HAR, including R3 which is the designated campsite location).

10.2.4 Light

There are no permanent sources of light within the MMHARCP, but the use of roads and campsites in the area result in temporary and localised sources of light (**Figure 10-1**). Permanent sources of light within the region include the Koolyanobbing iron ore mine to the south the HAR

There are no permanent sensitive receptors present in the local area and there are no permanent residences. The Aurora accommodation village is a non-permanent residence as it is associated with mining (**Figure 10-1**).

MRL operates the J4 and Carina mines which are located 40 to 50 km from the Proposal, respectively, as well as the Aurora Village south of the HAR. These operations all generate light emissions that may be evident from elevated vantage points within the MMHARCP as a faint glow on the horizon.

The Koolyanobbing Range mine operations (Cliffs Asia Pacific Iron Ore Pty Ltd) located approximately 50 km from the Proposal may be visible as pinpoints or isolated sources of light due to an uninterrupted view to the south (flat plains).

10.3 Assessment of potential impacts

The potential impacts of the Proposal on amenity can be categorised in terms of impacts on:

- amenity values (including visual landscape, scenic and visual aesthetic values, and recreational tourism) in a conservation park
- prominent and important landform features relative to this landscape character type
- social values (e.g. aesthetics or active use) of the landform(s) it supports (temporarily or permanently) including access, noise and vibration, dust emissions and light pollution.

It should be noted that the HAR and surrounds are relatively intact, but are not pristine. Disturbance has occurred at J5 and Bungalbin East, and throughout the wider HAR and MMHARCP, as a result of recreational use, mineral exploration and road/track development and usage (**Appendix 6-A**).

10.3.1 Visual amenity

A detailed assessment of the potential visual impact of the Proposal was undertaken by Bioscope Environmental (**Appendix 10-B**). The methodology used for this assessment was based on the protocols outlined by the WAPC (2007). The assessment included modelling to predict residual impacts arising from the Proposal, including changes to the landscape from viewpoints selected in consultation with OEPA and DPaW.

The mine pits at J5 and Bungalbin East occur within BIF- dominated landforms that occur throughout the region. The area of disturbance within the HAR is considered small and affects landform values that are represented elsewhere across the HAR, so the impact on the physical landform is not considered to be significant.

Bioscope Environmental (**Appendix 10-B**) found that localised changes to the existing landscape character will occur during the construction, operation and closure of the Proposal. Some of these changes will be temporary, but others will result in the permanent conversion of parts of the disturbance to a mining landscape character. The key aspects of the Proposal having the potential to create visual impacts include:

- Progressive clearing of native vegetation within mine pits, WRLs, supporting infrastructure areas and haul roads - up to 611 ha of native vegetation will be cleared.
- Development of open pits over an area of 61 ha at J5 and an area of 149 ha at Bungalbin East - the pit voids remaining following the cessation of mining operations represent a permanent change to the landform of the HAR.
- Development of WRLs on the plains adjacent to the J5 and Bungalbin East pits - these features will cover an area of up to 87.4 ha and 97.7 ha respectively and also represent a permanent change in the landform of these areas.
- Development of supporting infrastructure such as site offices, workshops and the stockyard area (run of mine) - these areas comprise 46 ha at J5 and 44.4 ha at Bungalbin East, and are temporary as all supporting infrastructure will be removed and the disturbance rehabilitated following cessation of mining.
- Development of the haul roads and linear infrastructure (comprised of water pipelines, telecommunications cables, borrow pits and vegetation and topsoil

stockpiles), which will require clearing of up to 124.3 ha of native vegetation – the haul roads will be rehabilitated when no longer required, so is considered to be a temporary impact.

- Dust generation during construction and operation of the Proposal as a result of earthworks, ore haulage, waste rock disposal and other transport activities, and during rehabilitation and closure earthworks - dust lift-off will also occur from exposed WRL surfaces, ore stockpiles, topsoil stockpiles and other disturbed areas during construction and operation, and from rehabilitated and unrehabilitated surfaces during and following site closure.
- Installation and use of lighting for safety and security of operations - there are few, if any, existing light sources in the HAR area so it is likely that lights from the Proposal will be visible from different locations throughout the region at night, particularly at higher-elevation locations. Light emissions are temporary in nature for the duration of operations and include:
    - static floodlights associated with mining operations
    - directional lighting around mining areas, WRLs and supporting infrastructure
    - vehicles moving around the site at night
    - light emissions from mine site buildings.

View Experience impacts on visual amenity

The significance of impacts on visitor view experience depends on the type and extent of modification to the existing landscape, whether these are temporary or permanent modifications, and people's responses to these changes. The sensitivity of these receptors to changes in visual amenity depends on a range of factors such as the duration of the viewing opportunity, the extent of screening/filtering of the view and the extent to which the change or modification to the landscape can be integrated within the existing landscape and views.

Visual impacts resulting from Proposal implementation have been categorised as being 'not evident', 'blending' or 'prominent', as described in **Table 10-3**, based on the classifications of WAPC (2007).

TABLE 10-3: VISUAL IMPACT CATEGORIES

Type of Visual Impact	Description
Not Evident	Development may be hidden, screened or not visible from specified viewing locations
Blending	Development may be evident, but generally not prominent in that it borrows from the existing landscape setting
Prominent	Development may be a dominant feature in the landscape, drawing attention to itself.

Source: WAPC and DPI (2007)

The predicted visual impact of the Proposal on view experience relates primarily to visual impacts associated with permanent landform changes (**Table 10-4**). There is also the potential for temporary visual impacts due to factors such as vegetation clearing, dust and night lighting (**Appendix 10-B**).

TABLE 10-4: VISUAL IMPACT SUMMARY FOR VIEW EXPERIENCE

View Point	Visibility	Overall Impact Rating
Koolyanobbing Track	Views of the HAR commence approximately 12.5km south of L3. The J5 mine will be visible from these viewpoints.	Prominent
Bullfinch-Evanston Road and Marda Track	The J5 mine will be visible from parts of the Bullfinch-Evanston Road, though the distance between the road and the mine reduces the visual impact. Due to the screening effects of landform and vegetation, it is unlikely that the J5 mine will be evident along the Marda Track until closer to the eastern end of this track.	Not Evident to Blending
Pittosporum Rocks/Menzies Track	The Bungalbin East mine will probably be visible from the Pittosporum Rocks/Menzies Track immediately west of L5, but it is unlikely that it will be evident from the more southwesterly or northeasterly sections of the Pittosporum Rocks/Menzies Track due to screening effects of landform and vegetation.	Not Evident to Prominent
Gus Luck/Mt Dimer Track	The Bungalbin East mine will be visible from elevated sections of this track and in closer proximity to the mine.	Not Evident to Prominent
Mt Manning Track	The J5 mine may be visible from sections of the Mt Manning Track depending on the elevation of the track and degree of screening (both of which vary along the track). However, the track is approximately 50 km north of the HAR, so the significance of any visual impact is reduced.	Not Evident to Blending
Mt Manning	There is a line of sight from Mt Manning point to the Western Range LCU and it is possible that the northern side of the J5 mine (such as ridgeline changes due to pit development) could be visible from this view point. However, Mt Manning is more than 40 km from J5 so the significance of any visual impact would be reduced. There is a line of sight from Mt Manning point to the Central and Eastern Ranges LCU, but it is expected that L5 will mask views of the Bungalbin East mine, depending on the elevation of the observer. In the event that the mine is visible, the	Not Evident to Blending

View Point	Visibility	Overall Impact Rating
	distance from this view point to the mine means that any visual impact would be reduced.	
Mt Dimer	The Bungalbin East mine will be visible from Mt Dimer.	Prominent
J5 and Bungalbin East	Development of the J5 and Bungalbin East mines means that it will no longer be possible to experience the views from those sites. However, the wide expanse of adjacent elevated areas means that similar views can be obtained from other locations adjacent to, and further afield from, these sites.	NA

In summary, based on the information discussed in **Table 10-4**, there will be views of both the J5 and Bungalbin East mines from the four main access routes (**Figure 10-1**) and two regional viewpoints (Mt Manning and Mt Dimer) as assessed in the VIA. However, the extent of the visual impact is variable and will depend on the position of the viewer in the landscape, the distance between the viewer and the mine(s), and the screening effect of landform and vegetation. Therefore, the visual impact rating varies across the MMHARCP from Not Evident to Blending to Prominent.

The overarching Visual Management Objective (VMO) for the Proposal is to ensure that visual impacts are reduced to as low as reasonably practicable and this aligns with the EPA's objective for amenity. In relation to the construction and operation phases of the Proposal, MRL aims to:

- undertake leading practice siting and design in order to reduce the visual impact of those areas affected by Proposal implementation
- protect and maintain the visual landscape character of those portions of the HAR not affected by Proposal implementation to ensure that these retain their visual prominence.

In relation to the closure phases of the Proposal, MRL will seek to restore and/or enhance those areas where visual landscape character has become degraded due to Proposal implementation, where practicable. The management targets and actions for visual landscape are outlined in the AMP and should be read in conjunction with the VIA (see also **Section 10.4**).

10.3.2 Visitor access and use

The development of the Proposal will not prevent visitor access to the MMHARCP and utilisation of informal camping areas outside the disturbance area. It is understood that the DPaW now prohibits camping at the Bungalbin East campsite (**Appendix 10-B**).

There are track closures proposed to prevent inadvertent public access to mining areas thereby ensuring the safety of visitors. The proposed track closures include:

- a section of the Marda track either side of J5
- the minor track that branches off the Mt Dimer Track leading to the southern end of the pit at Bungalbin East

- the track on the northern side of the HAR that branches off the Pittosporum Rocks track and leads to Bungalbin East.

To ensure continuity of access along the Marda Track, it is proposed to divert traffic around the J5 operation by utilising an exploration track that crosses the range west of J5 and re-joins the Pittosporum Rock/Koolyanobbing tracks to the east of J5.

All proposed track closures and the J5 diversion track are shown in **Figure 10-3**. A diversion track is proposed around the J5 mining area whilst existing tracks can be utilised to access the southern and eastern parts of the HAR where proposed tracks are closed around the Bungalbin East mining area. It should be noted that these track proposals are subject to agreement with DPaW and DMP; however, they are considered necessary to ensure public safety as well as an adequate level of public access to the HAR. No further clearing, other than routine maintenance, is required for the J5 diversion track as it follows an existing exploration track.

The activities undertaken in the MMHARCP as listed by stakeholders (**Section 10.2.1**) will still be able to be undertaken during both during and after implementation of the Proposal. The operational phase may deter people from visiting the MMHARCP even though access will be maintained, due to the perception of the impacts of the Proposal on amenity.

The values of MMHARCP (such as experience of a remote, outback landscape; a landscape with varied flora and fauna) and access to a range of recreation and tourism activities will still be attainable if the Proposal is implemented, as the Proposal disturbance area covers a small proportion of the BIF ranges within the MMHARCP available for access and use by visitors. Opportunities for four-wheel driving, sightseeing, wildflower viewing, bird/wildlife viewing, bushwalking/hiking, camping, photography, picnicking/barbequing, and relaxing will be available within areas of the HAR that are not directly affected by the Proposal.

The key responsibilities of the CPC are to preserve and promote appreciation of the natural environment and the provision of facilities for the enjoyment of reserves by the community. These responsibilities will still be undertaken within the MMHARCP. Due to the relatively low level of visitation to the MMHARCP, facilities provided by the CPC (as managed by DPaW) are likely to be minimal, similar to the level of management that is currently provided.

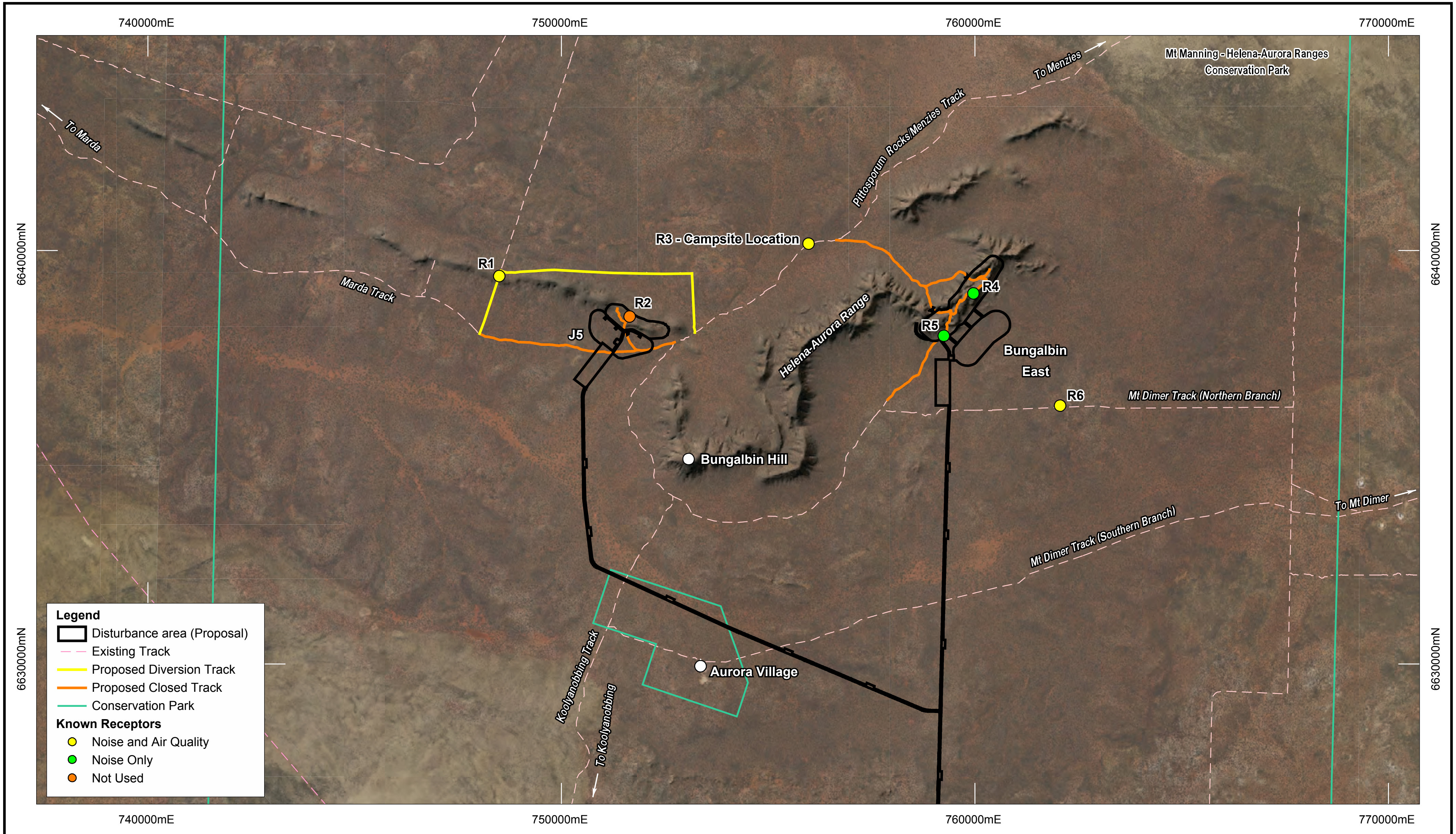
10.3.3 Noise and vibration

An assessment of the potential impacts of noise emissions from the Proposal was undertaken including modelling of predicted noise impacts from a range of scenarios (**Appendix 10-A**). The modelling predicts noise impacts during the worst case scenario based on wind conditions occurring from any direction (i.e. the extent of noise emissions being the furthest from the Proposal).

There are no 'sensitive receptors' within the MMHARCP as defined by the *Environmental Protection Noise Regulations 1997* (Noise Regulations). The Aurora Village is managed by MRL and is a ‘mining’ premise pursuant to the Noise Regulations. It is therefore not required to comply with the ‘highly noise sensitive' receptor criteria. Important areas for human use were used as ‘receptors’ in lieu of any formal receptors defined in accordance with the Noise Regulations (**Figure 10-1**).

With regard to ore haulage by truck with quad trailers travelling at 100 kilometres per hour (km/h), maximum noise emissions of between 60 dB and 75 dB are predicted to occur adjacent to the haul road (**Figure 10-4**):

- Noise levels decrease between 5 dB and 10 dB every few hundred metres away from the haul road, and the maximum noise emissions at receptors C3 (north west of J5; shown as R1 on **Figure 10-1**) and C2 (south east of Bungalbin East; shown as R6 on **Figure 10-1**) will be 25 dB and 30 dB, respectively (under a worst case scenario of wind in any direction).



Notes:
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Date: July 2016 | Rev: E | A4

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EXISTING TRACKS AND PROPOSED TRACK DIVERSIONS

Figure: 10-3

Noise emissions at receptor C1 are reported (predicted to be below 20 dB) as noise from ore haulage will be attenuated by the BIF range to the south.

Blasting will have the highest instantaneous noise emission of any mining activity (greater than haulage or night time mining operations). It is a one-off noise emission with a short duration and will be scheduled up to once per week. The maximum noise emission from blasting is between 130dB and 140dB and occurs at the blast location (**Figure 10-5** and **Figure 10-6**). The maximum noise emissions at the receptor sites are:

- 110 dB at C3 and 100-100 dB at C1 from blasting at J5
- 100-110 dB at C2 and 100 dB at C1 from blasting at Bungalbin East
- 90-100 dB at the Aurora village.

There are a number of factors that affect blast noise emissions, including the local geology, direction of blast pattern and effectiveness of stemming (**Appendix 10-A**).

Establishing appropriate acoustic criteria for the Proposal is problematic given its remote setting and the absence of permanent residences (i.e. sensitive receptors), as well as the subjective nature of amenity (particularly in relation to acoustics).

As there are no sensitive receptors adjacent to the Proposal in the form of permanent human occupation and no formal campsites located within the vicinity of the proposed mining areas, a worst case scenario has been adopted for the purpose of predicting noise emissions.

Noise and vibration emissions will occur during operational mining from drilling, blasting, material loading and unloading, earthworks machines in the mine pit and waste dump, ore haulage by trucks. Individuals or groups using the MMHARCP for camping, walking, four wheel drives and other recreational activities could be affected by noise emissions as a result of the Proposal (**Appendix 10-A**).

Noise emissions around 35 dB(A) will generally be low enough that the influence of background noise will result in the noise emission not being ‘technically tonal’, although that does not mean that some characteristics would not be audible (**Appendix 10-A**).

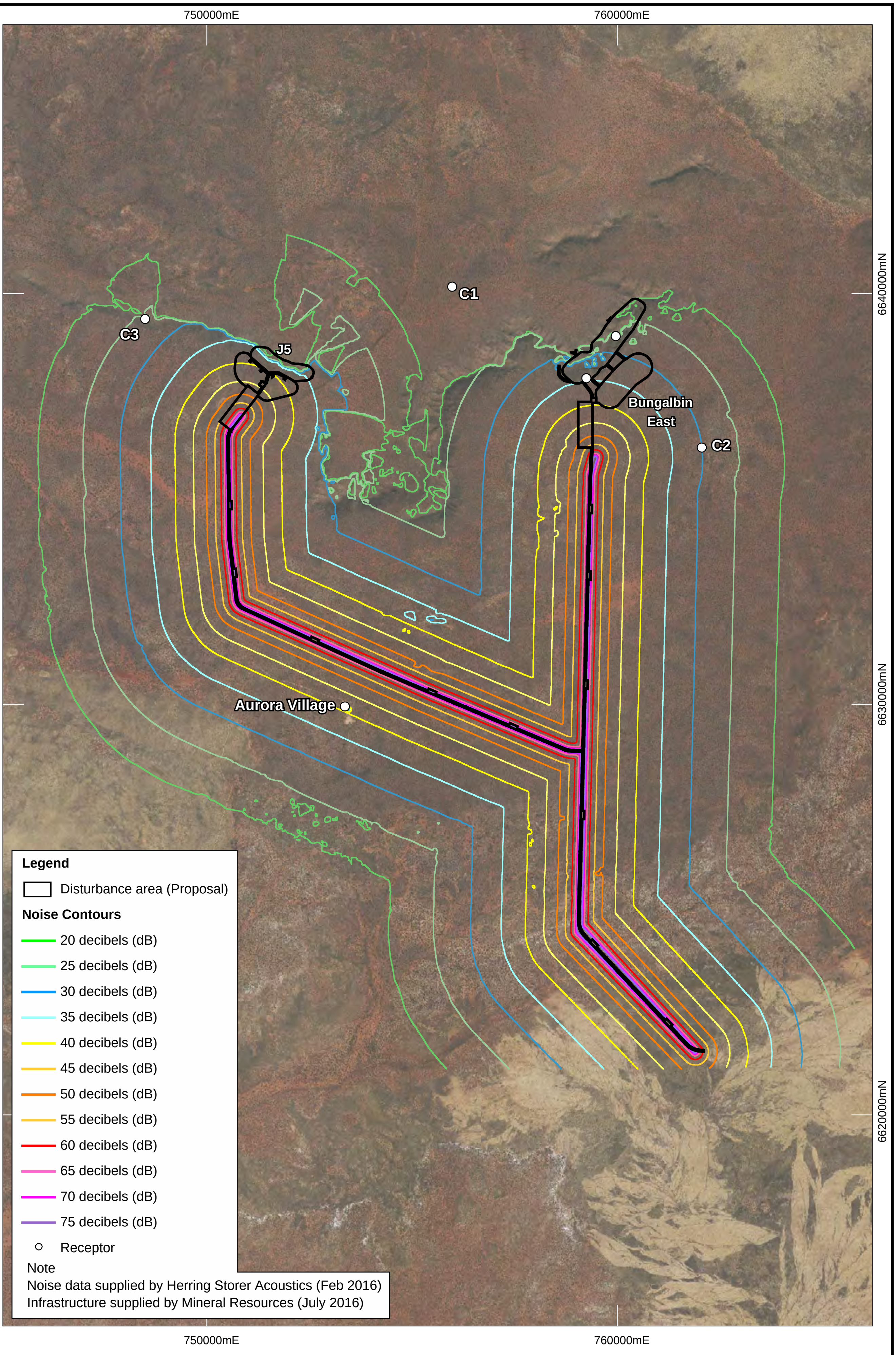
Noise emissions of 40 dB are comparable to background noises such as a babbling brook and a computer running, with 30 dB being heard as a whisper (Fox, S, 2016). Noise levels of 65 dB can be compared to an air conditioning unit running in the background and 85 dB a passing diesel truck or snow blower operating (Fox, S, 2016). Noise emissions of 110 dB, which is the modelled maximum blasting noise emission level, are comparable to a rock band or a jack hammer (over a duration of only a few seconds) (Fox, S, 2016).

10.3.4 Dust and total suspended particulates

An assessment of the potential impacts of the Proposal on air quality was undertaken by Pacific Environment Limited (**Appendix 10-D**). Modelling was undertaken to predict the volume of dust and TSP emitted by the Proposal compared to background levels.

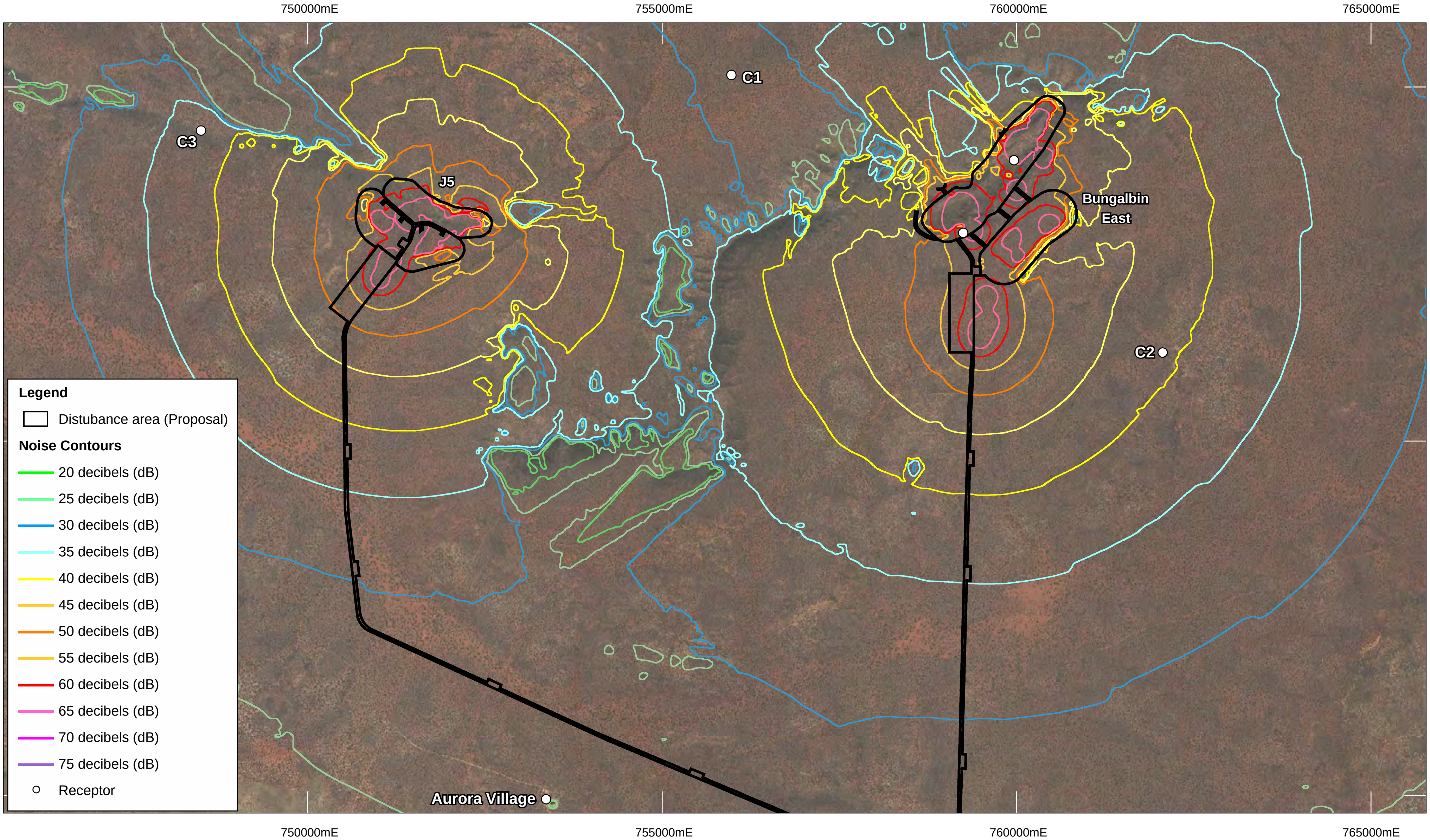
Dust deposition rates were predicted at four locations (defined as potential sensitive or discrete receptors, see **Figure 10-1**) between 3.5 km and 8.5 km from the J5 and Bungalbin East pits, respectively. In all cases, dust deposition is predicted to be within the threshold of acceptability of 2 g/m^2 per month. In addition, monthly cumulative maximum dust levels are also predicted to be within the threshold of acceptability of 4.2 g/m^2 per month (**Figure 10-7**).

The dust deposition threshold adopted for the assessment is based on NSW State Government standards, which is an accepted practice applied to dust assessments in WA (Appendix 10-D).



N	0 1 2km Scale 1:125,000 MGA94 (Zone 50) CAD Ref: g2378_J5_BE_PER_C10_F11_04 Date: July 2016 Rev: F A4	Author: Mineral Resources Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax (08) 9246 3202	**HAUL ROADS** **PREDICTED NOISE EMISSIONS**

Figure: **10-4**



Note:
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Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: Landgate (2012)

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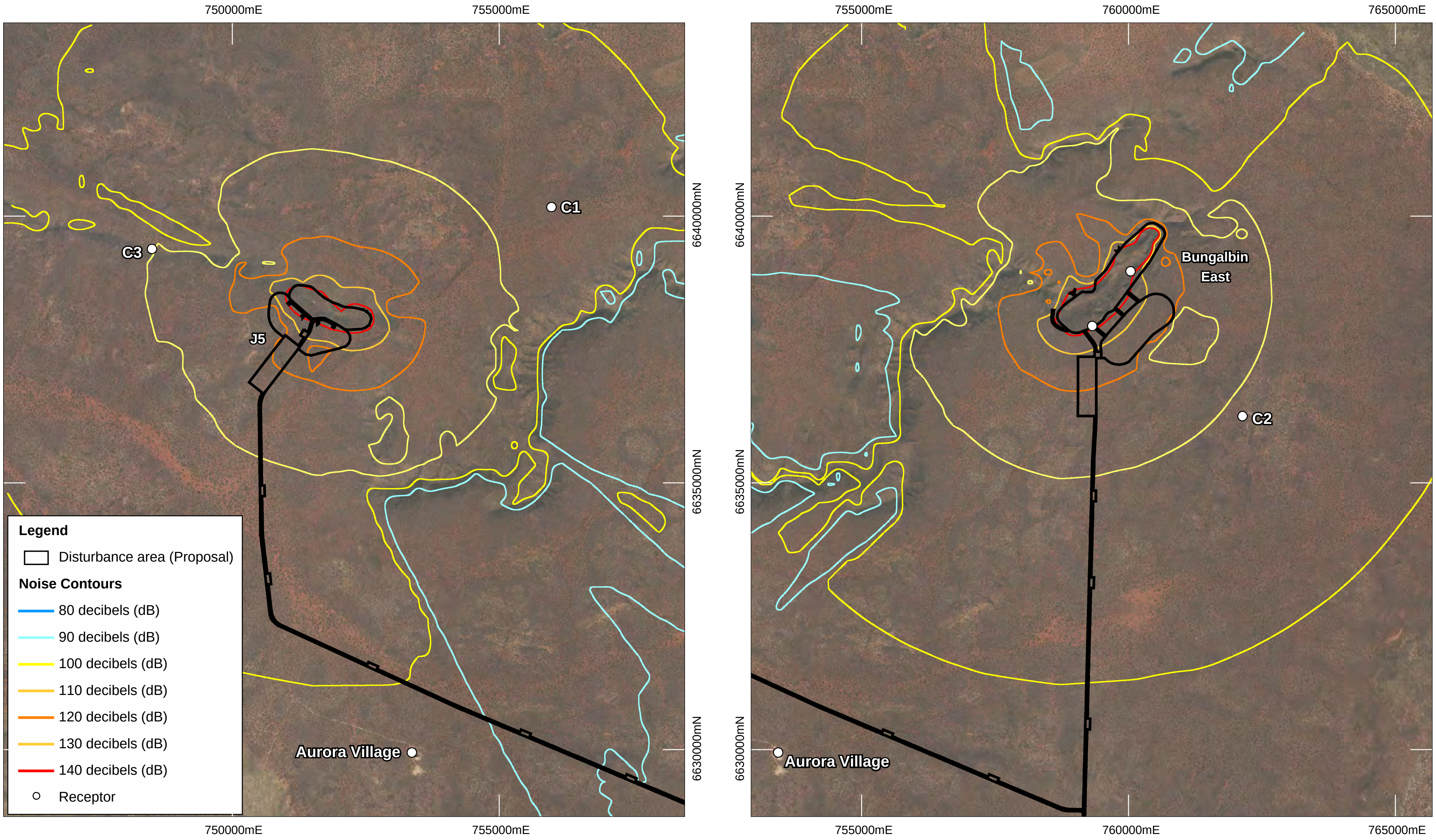
MINING
PREDICTED NOISE EMISSIONS

Figure:
10-5



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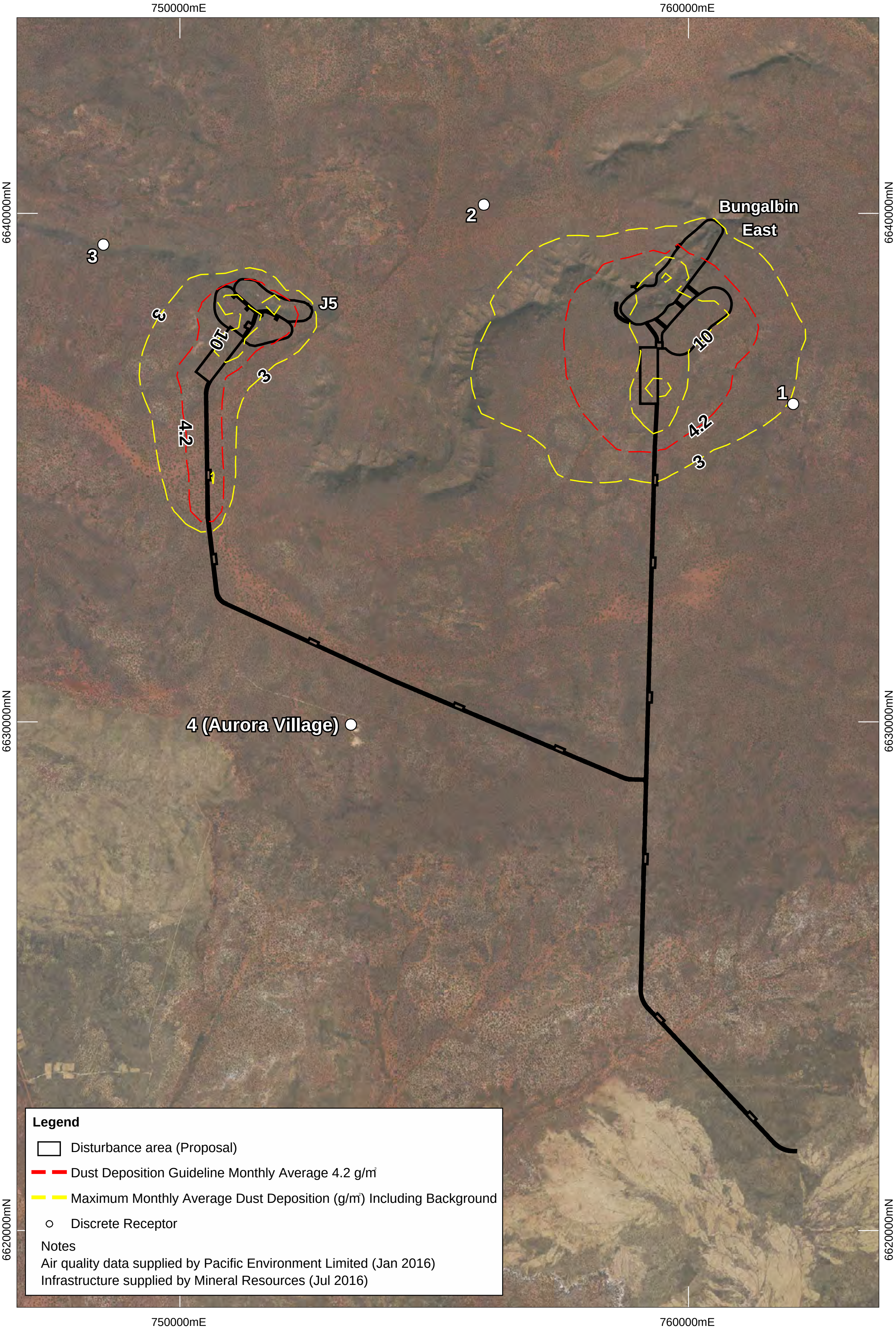
BLASTING
PREDICTED NOISE EMISSIONS

Figure:
10-6



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PREDICTED MAXIMUM DUST DEPOSITION LEVELS

Figure:
10-7

The emissions from construction activities (drill and blast, equipment and vehicle movements) account for about 80 tonnes of TSP per year, which is approximately 5 % of the emissions estimated from the operational phase of the mine (with the remainder from dust deposition and a small portion from PM_{10} and $PM_{2.5}$ concentrations) (**Appendix 10-D**).

Modelled TSP concentrations were compared to the Draft WA Department of Environment Regulation (DER) criteria and Kwinana Environmental Protection Policy (EPP) limit values of 82 micrograms per cubic meter (μg/m³) and 137 μg/m³, respectively, averaged over a 24-hour period (Environmental Protection Authority, 1999). These limits are set for permanent residences or receptors and are therefore considered overly conservative with regard to dust and TSP levels at the locations of important human use, which are temporary in nature (**Figure 10-8**).

The modelling predicts exceedance of the DER criterion of 82 μg/m³ for the maximum 24 hour average TSP concentrations (including background) at receptor locations one and two (shown as R6 and R2 on **Figure 10-1**), but is within the EPP limit of 137 μg/m³ (**Appendix 10-D)**.

The assessment by Pacific Environment also included analysis of PM_{10} and $PM_{2.5}$ concentrations, which are indicators usually associated with greenhouse gas emissions and human health impacts. These parameters are not discussed in this document as they are not described in the ESD (Environmental Protection Authority, 2015a) for the Proposal. Further details can be found in **Appendix 10-D**.

Sources of dust emissions associated with the Proposal including drilling, blasting, material loading and unloading, earthworks as well as operation of machinery in the mine pits, WRLs and haul roads, and wind erosion from stockpiles and open areas.

Dust emissions will be visible from surrounding areas within the MMHARCP from time to time and may affect amenity despite being within acceptable (regulatory) limits. The impact of dust on amenity depends on the distance from the mine site and weather conditions, particularly wind and rain, with concerns about dust emissions often relate to ‘visibility’ of dust plumes and dust sources (New South Wales Minerals Council Limited, 2011). Visible dust usually occurs as short-term episodes of high emissions, such as from blasting and amenity impacts from dust are usually associated with coarse particles and particles larger than PM_{10} (New South Wales Minerals Council Limited, 2011).

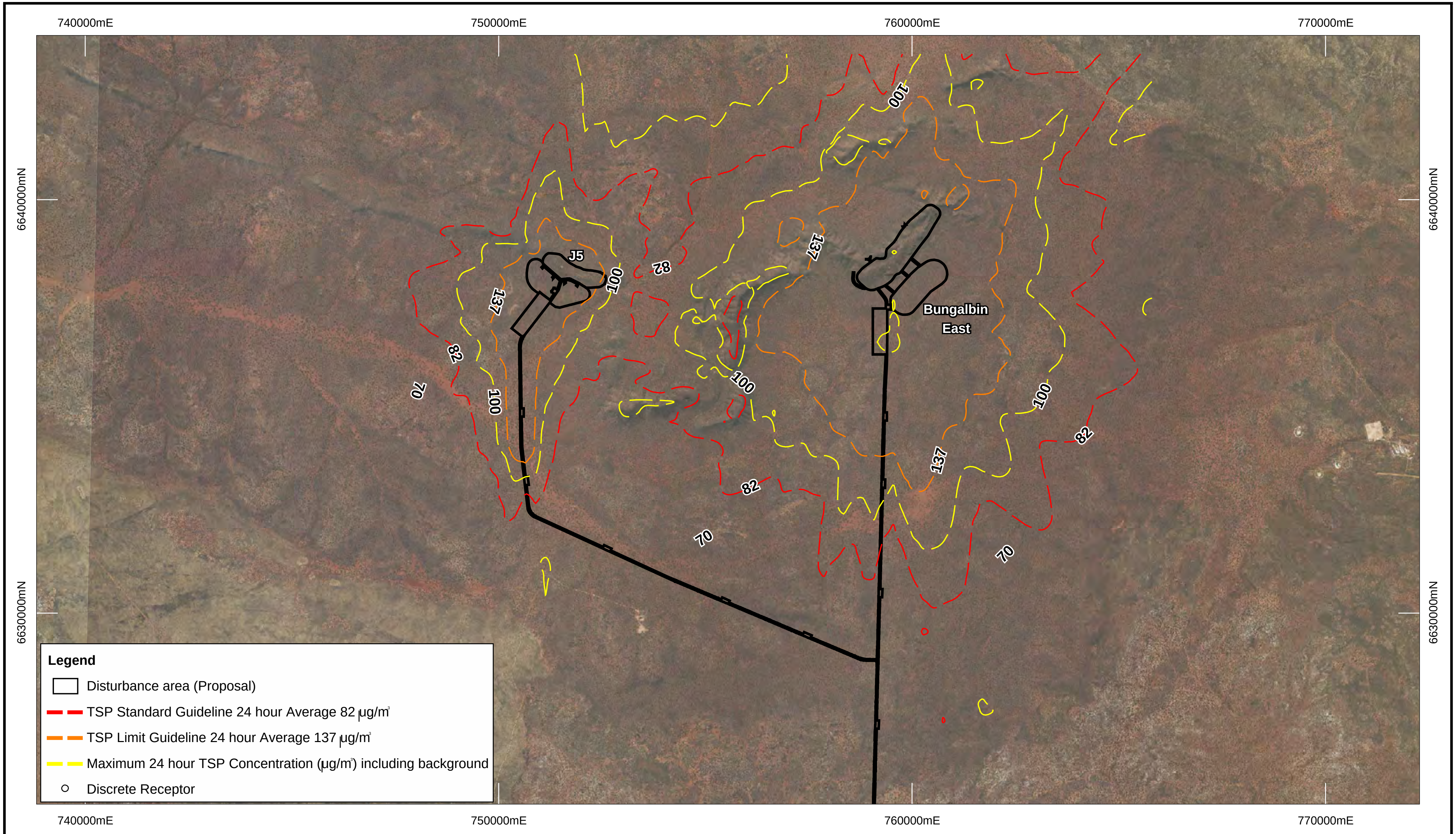
Dust generation resulting from the Proposal will be limited at the closure phase, as there will be less earthwork equipment and progressive rehabilitation will limit the areas of land exposed.

10.3.5 Light spill

Baseline studies have not been undertaken in regards to light spill emissions, but the VIA prepared by Bioscope Environmental (**Appendix 10-B**) notes that there are no permanent sources of light at the HAR or immediate surrounds. Permanent sources of light within the region include the Koolyanobbing iron ore mine to the south the HAR. The use of roads and campsites in the area result in temporary and localised sources of light, and these receptor locations are shown in **Figure 10-1**.

Light spill emissions will occur as a result of the Proposal as lighting will be required at various locations throughout the mine site operations for safety and security. Buildings will require lighting, earthmoving equipment and trucks will use headlights, and fixed or mobile directional lighting will be utilised in active mining areas and transport routes.

As there are few existing light sources in the MMHARCP area, it is likely that lights from the Proposal will be visible from different locations in the region at night. Higher elevation locations have the greatest likelihood of being impacted by light spill emissions (**Appendix 10-B**).



Note
Air quality data supplied by Pacific Environment Limited (Jan 2016)
Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: Landgate (2012)

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PREDICTED TSP EMISSIONS

Figure: 10-8

Light spill emissions will be temporary and limited during all phases of the Proposal as lighting in areas no longer required will be removed, thereby reducing the duration of impact. The topography of the HAR will provide a shielding effect from light spill on visitors and campers within some areas of the MMHARCP. However, as light from the Proposal will predominantly occur at night, light over-spill and night glow are likely to be visible.

As there are no permanent sensitive receptors within the MMHARCP light spill emissions as a result of the Proposal are not significant.

10.4 Proposed environmental management

The potential impacts to amenity will be managed through implementation of MRL's Environmental Management System for the Proposal, which includes an Amenity Management Plan (**Appendix 10-E**). The purpose of the AMP is to identify management and mitigation measures for the Proposal, including closure and rehabilitation outcomes, to ensure that residual impacts on amenity are not greater than predicted.

Management of visual amenity, visitor use and public access, and emissions such as dust, noise and light will be in accordance with the EPA project-specific objective to ensure that impacts to amenity are as low as reasonably practicable.

The overall approach to managing impacts on amenity is based on the EPA mitigation hierarchy of avoid, minimise and rehabilitate (and offset where applicable). The AMP sets out the management approach for amenity, the key elements of which are summarised below.

Visitor access and use:

- Avoid reduction of access to the MMHARCP for visitors and campers by restricting the size of the area needed for undertaking mining activities and that will be fenced off for safety and legal reasons.
- Minimise loss of public access to the MMHARCP by closing only those roads needed for operational and safety purposes and not excluding access to all of the known campsites within the Conservation Park.
- Areas no longer required for the Proposal will be rehabilitated throughout the duration of the Proposal with public access to mined areas provided at mine closure where possible (unless safety/legal reasons prevent this from occurring).

Visual landscape

- Areas no longer required for the Proposal will be rehabilitated throughout the duration of the Proposal.
- Siting Proposal infrastructure to ensure that these are obscured from public view as much as possible (by, for example, placing facilities within woodlands on adjacent plains rather than on foot slopes or ridges of the HAR).
- Selecting the design and colour of building and other infrastructure to provide a cohesive appearance. Colours used for these structures should be as close as possible to those found in the surrounding landscape.
- Using directional lighting or light shields, where practicable and safe.
- Aligning access roads to avoid a direct view of operations, where possible.
- Limiting clearing of vegetation to the minimum required by enforcing clearing controls.
- Minimising dust emissions as set out below.

- Establishing screening vegetation using local species, where practicable.
- Removing road barriers, traffic management signage and other signage when no longer required.
- Implementing progressive rehabilitation as much as possible.

Noise:

- Avoid significant off-site noise and vibration emissions from mining and associated activities that may result in amenity impacts on people outside the Proposal area to the extent it is reasonably practicable to do so (e.g. noise emissions above the Noise Regulations or ground vibration/air blast above Australian Standard 2187.2-2006 beyond the Proposal).
- Minimise noise and vibration emissions during construction, operations and closure and provide appropriate signage to visitors and campers in the MMHARCP regarding mining and blasting noise and vibration occurring in the vicinity.
- Rehabilitate cleared areas no longer required for the Proposal in a progressive manner to create additional noise buffers with vegetation.

Dust:

- Avoid activities that have the potential to generate dust to the extent it is reasonable practicable to do so and except where necessary for a safe and efficient operating mine site.
- Minimise dust emissions during construction, operations and closure through the use of dust suppression techniques on haul roads, active mining areas, waste rock landforms and other cleared areas.
- Rehabilitate cleared areas no longer required for the Proposal on a progressive basis, where practicable, to limit cleared or exposed areas that can generate dust emissions which will reduce the extent of dust generation over the long term.

Light:

- Lighting that results in light spill beyond the development envelope of the Proposal into the MMHARCP will be avoided where possible, with fixed or mobile directional lighting to be utilised.
- Light shields will be used where necessary, practicable and safe to minimise light spill emissions.
- Areas no longer required for the Proposal will be progressively rehabilitated, with no further lighting required in these areas.

Details of the environmental management and mitigation measures proposed for amenity are also detailed in the AMP. To ensure that residual impacts on amenity are not greater than predicted, the AMP identifies management targets, management actions and monitoring to be undertaken in relation to amenity. Further details can be found in **Appendix 10-E**.

10.5 Residual impact

The AMP has been prepared to ensure that impacts to amenity are reduced as low as reasonably practicable and will be implemented by MRL for the Proposal to manage potential impacts on amenity.

There will be no residual impacts in relation to dust, noise and light emissions, all of which are associated with the construction and operations phases of the Proposal. Once rehabilitation and decommissioning are complete there will be no further impacts of this nature.

As discussed in the VIA (**Appendix 10-B**), the Proposal will result in localised but permanent alterations to the contour of ridgelines and crests from mining activities. Open pits will be developed and will remain as voids with pit walls that may be subject to slope failures and will not be conducive to revegetation.

New landforms (WRLs) will also be developed adjacent to the HAR (185.06 ha) and will result in localised alterations to landform contours and surface drainage patterns. Residual impacts arising from altered hydrology, including drainage shadows, are not expected to be significant, particularly as there are no surface water dependent vegetation species in the area (**Appendix 5-A**; **Appendix 9-A**).

There will be residual impacts on visitor access and use as well as the visual landscape, although these are not considered to be significant for the following reasons:

- There are no permanent sensitive receptors or permanent residences within the MMHARCP, and visitation is considered to be low.
- A number of tracks currently provide access to the MMHARCP and it is expected that most of these will remain open to public access during the life of the Proposal. Limited local track closures around the two mine pits will occur to ensure public safety (**Figure 10-3**).
- There are areas of the MMHARCP (including areas at lower elevations) that do not have a clear line of sight to the Proposal i.e. the Proposal is not visible from these locations. Visitors can still experience the remote and natural environment of the MMHARCP at the same time that mining is occurring.
- The disturbance area of the Proposal within the MMHARCP is small compared to the area of the MMHARCP that remains undisturbed, and the Proposal is potentially located within an area of the MMHARCP which has the same landform values also represented elsewhere across the MMHARCP.
- The mine pits will remain as open voids, however the southern pit at Bungalbin East will be partially backfilled and the WRLs will be constructed in a manner that ensures these new landforms will be safe, stable, non-polluting and able to sustain native vegetation in the long term (**Appendix 10-B**).
- The Rehabilitation and Mine Closure Plan developed for the Proposal outlines the rehabilitation activities and the monitoring and maintenance framework that will be implemented to ensure the success of the mine rehabilitation and closure programs (see **Appendix 12-D**). This framework includes monitoring for physical stability and erosion of rehabilitated areas and allows for repair works where required and various monitoring methods to be implemented, with monitoring continuing until the completion criteria agreed for each of the closure domains have been achieved.

10.6 Predicted outcome

The EPA objective for amenity is to ensure impacts to amenity are reduced to as low as reasonably practicable.

The potential impacts of the Proposal on the amenity of the area are important to consider given the use of the MMHARCP for a variety of recreation purposes. Individuals or groups using the MMHARCP may be affected by dust and noise emissions as a result of the Proposal, and there will be impacts on visual amenity arising from light spill emissions and alterations to landforms.

The level of impact to amenity will vary during the different phases of the Proposal, i.e. construction, operations and closure, with some impacts being more temporary in nature. For example, noise impacts from blasting will occur over only a few seconds per day, but changes to some aspects of the visual landscape from development of the mine pits and WRLs will be permanent.

MRL has demonstrated that the Proposal has been designed to minimise impacts on amenity and has appropriate management measures in place to actively monitor and manage residual impacts on amenity as a result of implementation of the Proposal.

The Proposal can therefore meet the EPA objective to ensure that impacts to amenity are reduced to as low as reasonably practicable.

11. HERITAGE

11.1 EPA objective, policies and guidance

The EPA objective for heritage is:

- to ensure that historical and cultural associations, and natural heritage, are not adversely affected.

The policy and guidance documents referenced as part of the field investigations and impact assessment are provided in **Table 11-1**.

TABLE 11-1: LEGISLATION, POLICY AND GUIDANCE CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
EPA (2004). Guidance Statement No. 41: Assessment of Aboriginal Heritage. Perth, Western Australia.	Addresses the EPA's position on the assessment of Aboriginal heritage. It provides information that the EPA will consider when assessing proposals where Aboriginal heritage is a relevant environmental factor.	Predicted outcome of Proposal related to the EPA's requirements (PER **Section11.6**).
EPA (2007) Report 1256: Advice on the Areas of the Highest Conservation Value in the Proposed Extensions to Mount Manning Nature Reserve.	Paragraph 4.6 deals with Aboriginal heritage, noting that "there are many Registered Aboriginal Sites scattered throughout the MMR study area"	There are no such Registered Sites within the Proposal area, but there are fourteen DAA-listed Other Heritage Places within or in general proximity to it. Report 1256 was used as background material for production of the PER. Impacts of the Proposal on DAA-listed Other Heritage Places and areas of Aboriginal significance identified in the course of Aboriginal heritage surveys are considered below, along with management and impact-mitigating proposals.
EPA (2015) Environmental Assessment Guidelines for Preparation of Management Plans.	Provides guidance on the contents and objectives of project-specific Management Plans.	Used as background for production of management plans for the DAA-listed Other Heritage Places addressed below in order to ensure that the EPA objective for heritage, as stated above, is addressed.

Legislation, Policy and Guidelines	Key Aspects	Application
Non-EPA policy and guidelines		
Department of Aboriginal Affairs (DAA) and Department of Premier and Cabinet (DPC), 2013. Aboriginal heritage – due diligence guidelines. Version 3.0. Perth, Western Australia	To assist land users, these guidelines provide information on assessing, avoiding and managing Aboriginal heritage sites and on the conduct of Aboriginal heritage surveys.	Used for general reference in planning and undertaking heritage surveys. Specific use as follows. Paragraph 2.18 offers guidance on the selection of appropriate Aboriginal groups and individuals who should be involved in consultation and Aboriginal heritage surveys, namely: • Determined Native Title Holders • Registered Native Title Claimants • Persons named as informants on DAA site recording forms • Other Aboriginal people who can demonstrate relevant cultural knowledge of a particular area There has been no determination of native title over the Proposal area; there are no currently registered native title claims, but former registered claims are detailed in Section 11.4 and senior members of those groups were involved in heritage surveys; all living persons named as informants by DAA have been or are being engaged in the consultative process regarding the Proposal area; and culturally relevant persons have been identified by anthropologist R. O'Connor and engaged in consultation and heritage surveys.

This PER has been prepared to be consistent with all policy and guidance documents referenced in **Table 11-1**.

11.2 Existing environment

11.2.1 Aboriginal heritage

At the time of European colonisation, the Proposal area and surrounding lands were within a transition zone between the Bibbulmun people of the Southwest and the tribal groups who inhabited the Desert regions of Australia's interior; collectively known nowadays as "Wangkayis" or "Wongis" (Bates 1985: 55 and 61-69). Tindale (1974) refers to these intermediate people as the Kelamaia, but his field notes reveal that this was the name for the language spoken in that region, whereas Kubrun was the name of the people which he collected.

As with other Aboriginal names, “Kubrun” has no standardised rendering in script and also appears as “Gubrun”, “Kaparn”, “Kabu(d)n” and “Kapun”. Bates also noted that the eastern Bibbulmun groups, being the Ballardong families, had intermarried with the Kubrun people and that some of them had also been initiated into Kubrun culture. That pattern of intermarriage has continued up to the present day, although tribal initiations have not been practised by either group for at least two generations.

Archaeological evidence of the use of the country by Aboriginal people is manifested in the landscape by stone artefact scatters, which evidence the presence of former camping places or resources; quarry sites, where cherts, jasperlites or other sought-after lithic resources were accessed and fashioned into tools and weapons; scarred trees, where a portion of bark has been removed to make carrying dishes or weapons such as spear-throwers or shields; water trees, where the natural growth pattern of the tree has been modified by human action to form a water-retaining reservoir in the bole; rockholes; gnamma holes and stone arrangements, which may indicate the presence of former ceremonial or ritual sites. Some of these are known to today’s descendants of the Kubrun people; others are lost to history but may be identified in the course of Aboriginal heritage surveys.

Other current Aboriginal connections to country, which are not confined to “sites” or to specific areas in the landscape, include the continuing use of bush resources for food and medicines and the transmission of cultural knowledge from the senior generations to younger persons. This transmission commonly takes place in the course of Aboriginal heritage surveys.

The WA Department of Aboriginal Affairs formally recognises Aboriginal heritage by classifying locations with heritage value as either a ‘Registered Site’ (RS) or an ‘Other Heritage Place’ (OHP). Locations having OHP status are further classified as either Stored Data/Not a Site’ or ‘Lodged’:

Stored Data/Not a Site means the place has been assessed by the Aboriginal Cultural Material Committee and does not meet the requirements of Section 5 of the *Aboriginal Heritage Act 1972* (AH Act).

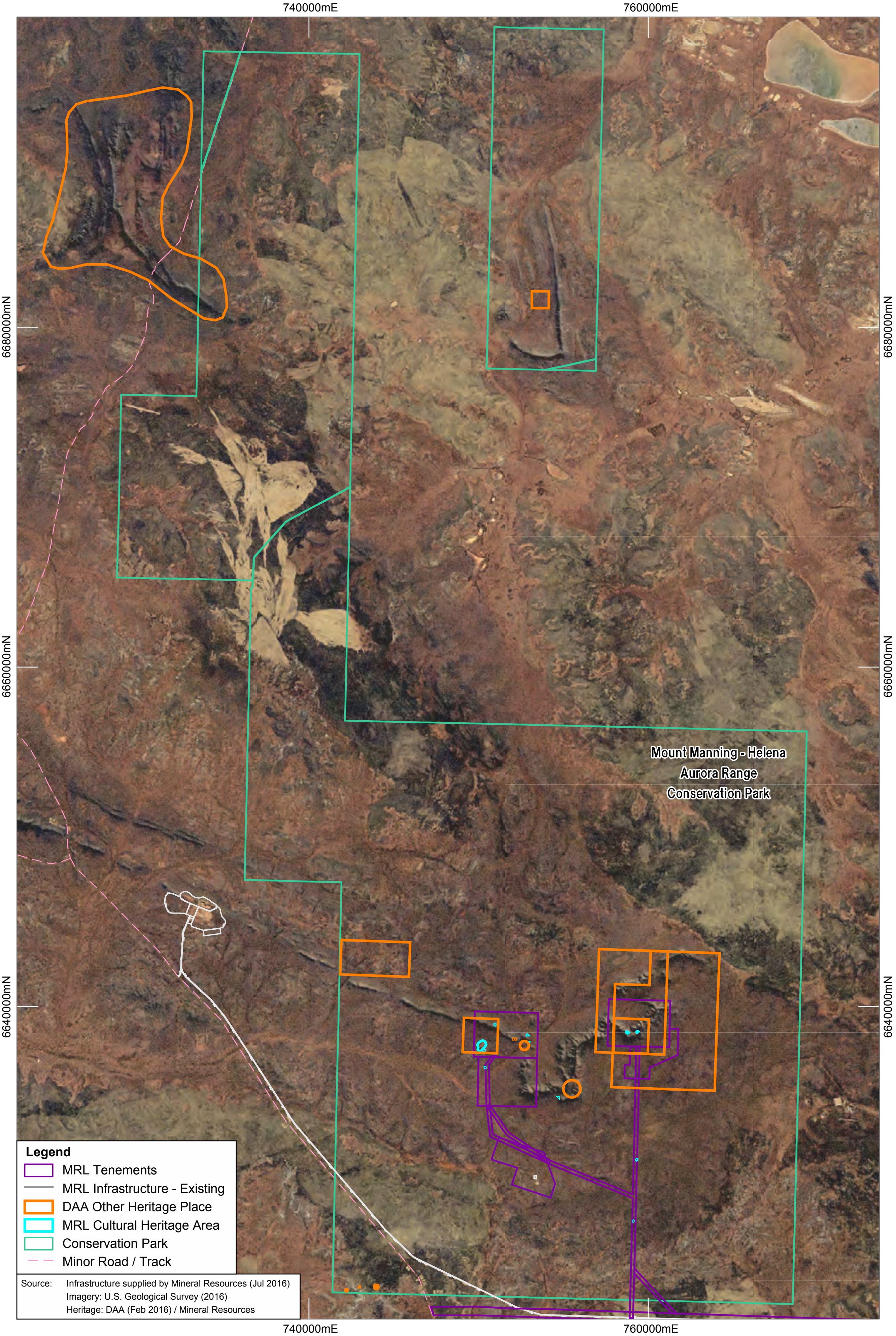
‘Lodged’ means information has been received in relation to the place, but an assessment has not been completed to determine if the place meets the requirements of Section 5 of the AH Act. Where the requirements of that Section are met, registration of the site follows.

There are no registered Aboriginal Heritage Sites within the MMHARCP. However, there are fourteen OHPs within the MMHARCP, of which seven occur in proximity to the Proposal. The OHPs were identified through the Department of Aboriginal Affairs (DAA) Aboriginal Heritage Inquiry System (AHIS). DAA ID No 20359 (KY 45 – Die Hardy Ranges) is listed as Stored Data/Not a Site: all of the remaining OHPs are classified as Lodged. These OHPs are listed in **Table 11-2** and shown in **Figure 11-1**.

From 2008 to 2016, MRL has undertaken seven archaeological and nine ethnographic Aboriginal Heritage Surveys to better define the boundaries of the OHPs in proximity to the Proposal and to search and define any further culturally significant areas in proximity to the Proposal that are not currently known[2]. These surveys comprised:

- three ethnographic/archaeological joint Aboriginal Heritage Surveys covering both J5 and Bungalbin East (Cecchi, 2014a; O'Connor, 2008a; 2012)
- six ethnographic (Cecchi, 2014c; 2015a; O'Connor, 2009a; 2009b; Mathieu, 2014a; 2014b)and four archaeological (Cecchi, 2014d; 2015b; O'Reilly, 2009a; 2009b) Aboriginal Heritage Surveys separately targeting J5 and Bungalbin East .

[2] Surveys have also been conducted for the nearby Carina and J4 projects.



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: U.S. Geological Survey (2016)
Heritage: DAA (Feb 2016) / Mineral Resources

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ABORIGINAL HERITAGE OF THE MMHARCP

Figure:
11-1

TABLE 11-2: OTHER HERITAGE PLACES WITHIN THE MMHARCP

Site Name	AHIS No.	Type
KY19**	20336	Artefact / Scatter, Mythological, Camp, Water Source, Other: Rockhole
KY19 (Defined)*		
J5 Rockhole 1**	29178	Water Source
J5 Rockhole 2**	29179	Water Source
KY28**	20342	Mythological
Aurora Range Women's Place**	18726	Ceremonial, Grinding Patches / Groves, Historical, Rockshelter
Helena Cave**	18732	Artefact / Scatter, Ceremonial, Engraving, Historical
Helena/Aurora Ranges Gully	18730	Historical, Mythological, Camp, Hunting Place, Water Source
Helena – Aurora Range Engraving**	18731	Engraving
Mt Manning	5648	Water Source
Rockholes	18729	Historical, Water Source
KY20	20146	Man-Made Structure, Other: Lizard Traps
KY21	20337	Artefact / Scatter, Rockshelter
KY35	20348	Mythological
KY45– Die Hardy Ranges	20359	Mythological, Natural Feature

* The boundary of DAA ID No 20336 (KY19) was defined accurately by archaeologist John Cecchi and representatives of the Kaparn and Kelamaia Kabu(d)n groups in the course of an Aboriginal Heritage Survey during October 2014 (Cecchi, 2014c; 2014d).

**Seven Other Heritage Places in proximity to the Proposal

Due to the number of Aboriginal heritage surveys which have been undertaken throughout the HAR, it is very unlikely that there are further cultural sites that have not been identified. The Kaparn/Kubrun/Kelamaia-Kabu(d)n Peoples, who have participated in those surveys, are highly skilled in the recognition of their cultural areas, further supporting the above conclusion.

Nonetheless, management plans as detailed below, will be in place in order to ensure appropriate and timely responses in the event of such additional areas being discovered.

The OHP DAA ID No 20342 (KY28) has yet to be positively identified on the ground. The position of this mythological site has been related by Wangkayi custodians, some of whom are now deceased, on the basis of similarity to landforms in their traditional countries in the desert regions to the east of Kalgoorlie and is therefore approximate. All but one of the custodians of this OHP have been consulted. A final Aboriginal Heritage Survey with the last remaining custodian/informant for KY28 is scheduled to be completed in 2016

In addition to the OHPs there are six MRL-defined cultural heritage areas that occur in proximity to the Proposal but are not recorded in the AHIS. These areas are listed in **Table 11-3** and shown in **Figure 11-1** and **Figure 11-2**.

Of the six MRL-defined cultural heritage areas, only one occurs within the disturbance area (Site 252). Proposed management of Site 252 is discussed below.

TABLE 11-3: MRL-DEFINED CULTURAL HERITAGE AREAS

Site Name	AHIS No	Type
Damon's Quarry 1	Not in AHIS	Quarry
Damon's Quarry 2	Not in AHIS	Quarry
Damon's Rockholes	Not in AHIS	Rockholes (2)
Damon's Scar Tree	Not in AHIS	Scar Tree
Site 270	Not in AHIS	Scar Tree
Site 252	Not in AHIS	Artefact scatter

In 2008, anthropologist R O'Connor noted rock shelters in the Bungalbin East area, several of which were inspected at that time by the Aboriginal representatives (O'Connor, 2008a). He recommended a detailed inspection of all accessible shelters. In 2009 archaeologist T O'Reilly inspected an unspecified number of these and concluded that none of them contained visible indications of occupation and insufficient depth of deposit to justify further analysis (O'Reilly, 2009a).

In 2012 O'Connor revisited the area with the Ballardong representative and two of the rock shelters were firmly identified as being previously-recorded OHPs – namely OHP DAA ID 18726 and 18732, as shown in **Figure 11-2** (O'Connor, 2012). In 2015, archaeologist J Cecchi carried out detailed analyses of all accessible rock shelters in Bungalbin East, which were of sufficient size to allow human occupation (Cecchi, 2015b). The 21 rock shelters thus inspected are also shown (numbered 1-21) in **Figure 11-3**.

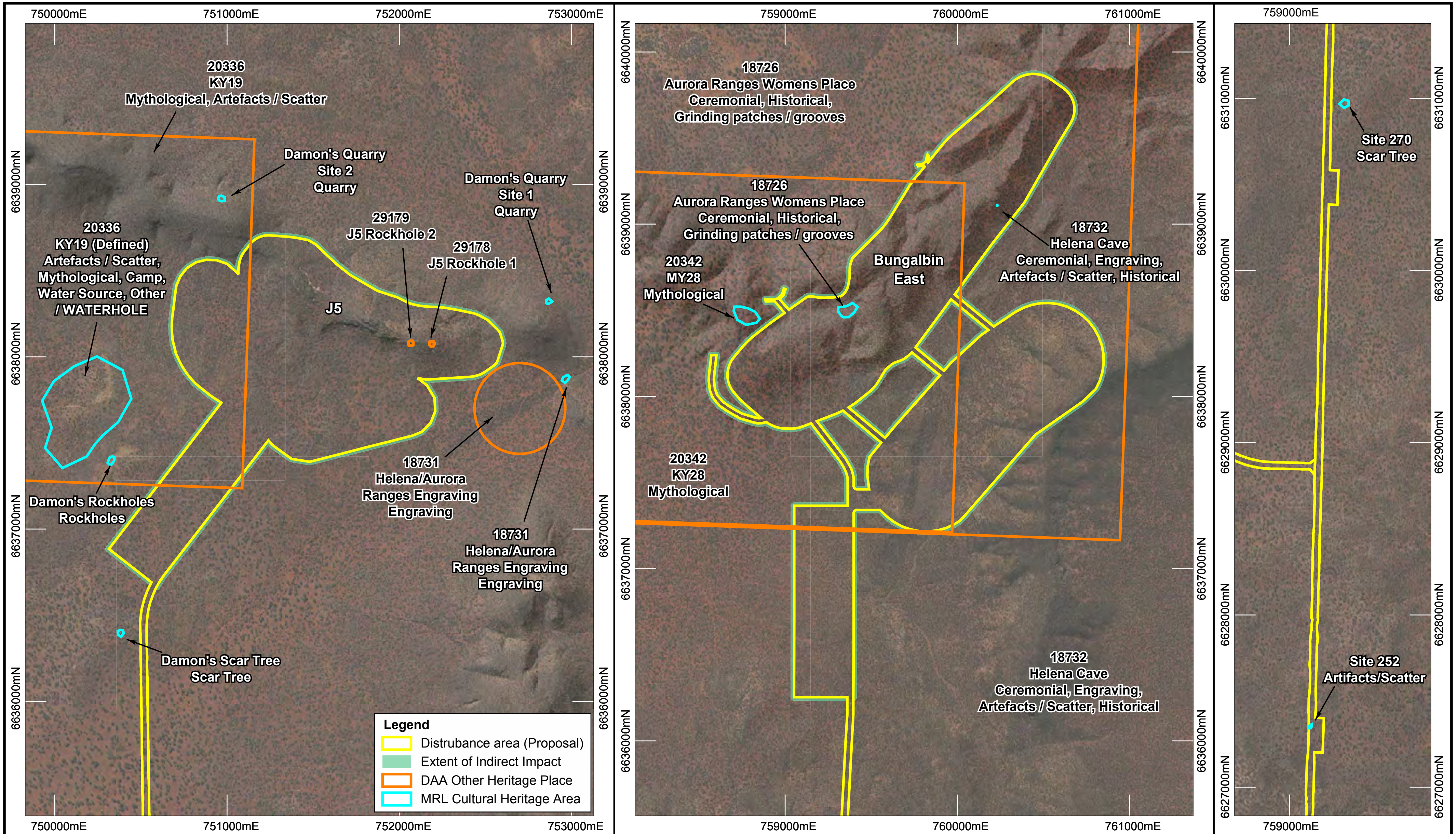
Cecchi (2015b) reported that these 21 shelters have the potential to contain archaeological deposits. Importantly, Cecchi noted that there is no surface Aboriginal cultural material visible on the floors of the rock shelters and their status vis-à-vis the AH Act is therefore moot until such time as the required management recommendations are carried out (see **Section 11.4.4**).

There is currently no determined Native Title Holder over the Proposal and no relevant Registered Native Title Application. The area has been previously encompassed in a number of Native Title Claim applications. These applications are summarised in **Table 11-4**.

The main families making up all of the four below-listed native title claims are the Sambo and Champion families respectively. Elders for both families live in Kalgoorlie, but extended family members live in Perth, Ceduna, Adelaide, Sydney and Melbourne.

TABLE 11-4: HERITAGE – NATIVE TITLE CLAIM APPLICATIONS

NNTT File No	Name	Date lodged	Status/Date
WC2013/009	Kaparn People	11/11/2013	Dismissed 26/08/2015
WC1999/029	Central West Goldfields People	26/02/1999	Dismissed 26/08/2010
WC1997/100	Kalamaia Kabu(d)n People	25/11/1997	Dismissed 11/12/2009
WC1995/27	Gubrun People	27/07/1995	Dismissed 24/08/2007



Source: Infrastructure supplied by Mineral Resources (Jul 2016)
Imagery: Landgate (2012)
Heritage: DAA (Feb 2016) / Mineral Resources

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CAD Ref: g2378_J5_BE_PER_C11_F11_02
Date: July 2016 | Rev: E | A4

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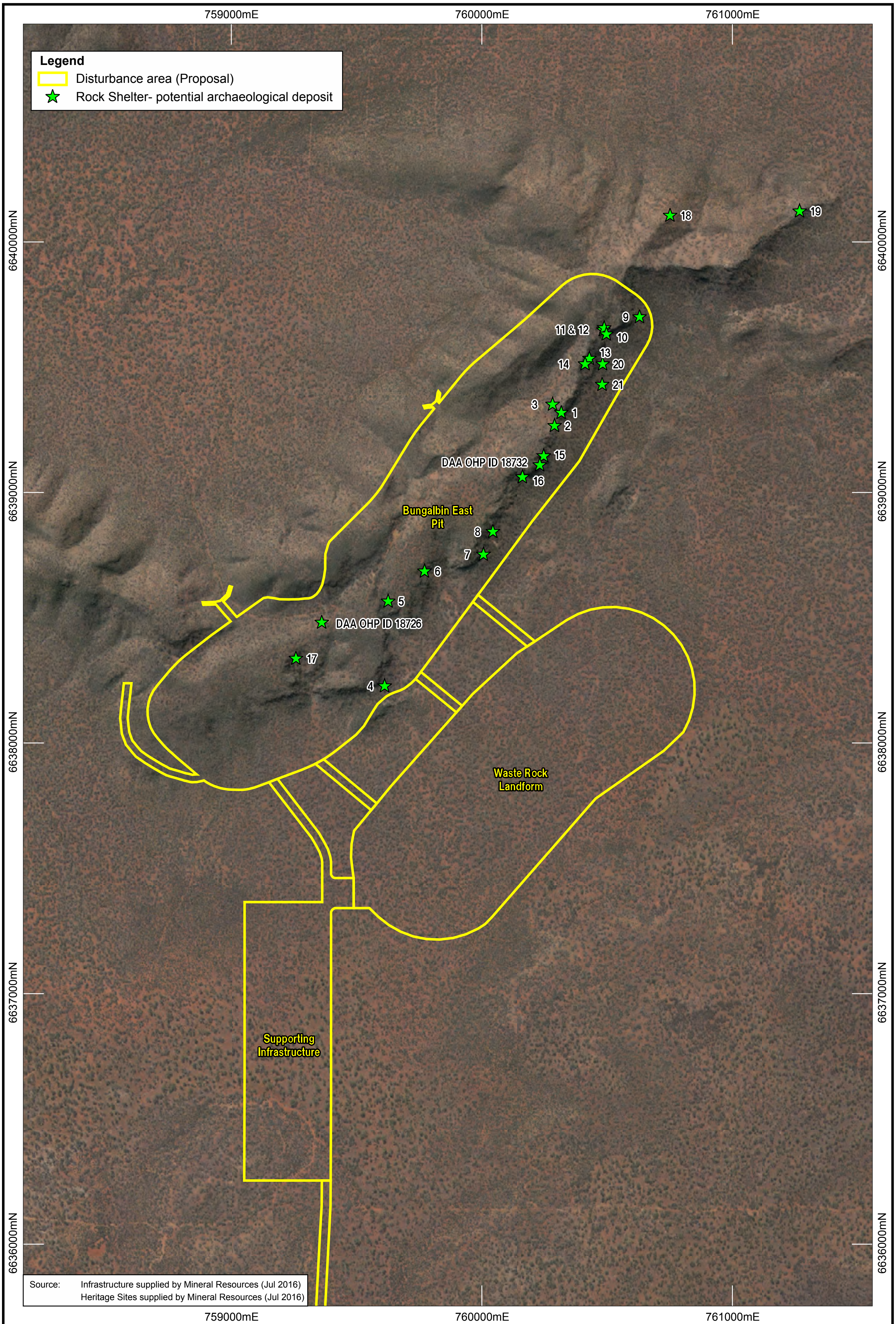
ABORIGINAL HERITAGE SITES

Figure:
11-2



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Date: July 2016 | Rev: B | A4

Author: Mineral Resources

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BUNGALBIN EAST
ROCK SHELTER LOCATIONS

Figure:
11-3

The original Ballardong native title claim extended east and northeast from its currently determined boundary and included the Proposal area. In 1997, however, its boundary was revised westwards to form a common boundary with the Gubrun and later Central West Goldfields claims and does not include the Proposal area. The Ballardong native title claim now falls within the Southwest Native Title Settlement and Indigenous Land Use Agreement. It is therefore not relevant to the Proposal area.

MRL does not have any Heritage Agreements with the above groups. However, MRL is aware of its responsibilities regarding the AH Act and has always consulted extensively with both the Native Title Groups and the Champion and Sambo families on all planned disturbance in relation to the Proposal. In addition, as members of the Ballardong group are still listed by the DAA as Registered Informants for certain OHPs within the MMHARCP, MRL has also involved them in Aboriginal heritage surveys, in accordance with clause 2.18.c of the Aboriginal Heritage Due Diligence Guidelines (see **Table 11-1**).

11.2.2 European heritage

MRL undertook a search of the inHerit database operated by the Heritage Council. The database contains comprehensive information about cultural heritage places listed in the State Register of Heritage Places, local government inventories and other lists, the Australian Government's heritage list, and other non-government lists and surveys.

There are no known sites of European heritage in or around the Proposal. The Proposal area does straddle an informal stock route use to herd sheep from Menzies to Mt Jackson. The former Menzies coach road also passes through the Proposal area.

11.3 Assessment of potential impacts

The potential impacts of the Proposal on Aboriginal heritage are:

- disturbance of Aboriginal heritage sites and/or cultural associations with those sites
- temporary and/or permanent constraint on traditional cultural activities
- alteration of Aboriginal heritage and cultural values associated with the Conservation Park.

11.3.1 Disturbance of Aboriginal heritage sites and/or cultural associations

Of the seven OHPs occurring in proximity to the Proposal, the following five will be removed by the Proposal:

- J5 Rockhole 1 (29178)
- J5 Rockhole 2 (29179)
- KY28 (20342)
- Aurora Range Women's Place (18726)
- Helena Cave (18732)

Management of these areas, and of sites in adjoining areas that will not be subject to direct disturbance, is discussed in **Section 11.4**. Also discussed in **Section 11.4** is the proposed management of rock shelters recorded during surveys which occur within the Proposal disturbance area and will be lost if the Proposal is implemented.

It is possible that discoveries of skeletal material or other Aboriginal cultural materials will be discovered in the course of implementing the Proposal. The steps to be taken in this event are outlined in **Section 11.4.6**.

11.3.2 Constraints on traditional cultural activities

Five OHPs will be removed and therefore the Ballardong, Kaparn and Kelamaia Kabu(d)n Peoples will no longer be able to access these places. Site 252 is expected to remain accessible provided disturbance can be avoided by a minor realignment of the Bungalbin East/J5 haul road and relocating the adjacent topsoil/vegetation stockpile; all within the development envelope of the Proposal. If road realignment is not feasible, then Site 252 will no longer be accessible to the Aboriginal groups. However, the groups would carry out the proposed removal of the artefact assemblage from the site and those items would then be accessible to them in the deposit location chosen by them.

The Kaparn and Kelamaia-Kabu(d)n Peoples often ‘go bush’ to collect food and medical plants; however the Proposal will not adversely affect this activity. In addition, collection of tree branches for manufacture of tools and other implements will similarly not be affected by the Proposal. The main reason for this is that plants and trees that are required for these traditional cultural activities do not occur on the ranges where much of the disturbance associated with the Proposal will occur.

The Kaparn and Kelamaia Kabu(d)n Peoples will have unrestricted access to the OHPs elsewhere in the MMHARCP. This document notes that, in the course of the Aboriginal heritage surveys, the Kaparn and Kelamaia Kabu(d)n Peoples have approved the associated management and mitigation plans. MRL will continue to work closely with the members of the Kaparn and Kelamaia Kabu(d)n groups to ensure that execution of the Proposal will not adversely affect their access to and enjoyment of all other areas of the MMHARCP.

Two OHPs associated with the Ballardong people will be removed, namely OHP DAA ID 18726 and DAA ID 18732. Traditional cultural activities associated with these OHPs have not been practised for at least two generations – there have been no births in 18726 or initiations in 18732 during that period of time. The Ballardong people associated with these OHPs have approved the management and mitigation plans proposed for them, as they will serve to record their former usage. As is the case with the Kaparn and Kelamaia Kabu(d)n group members, the particular Ballardong families continue to visit the MMHARCP and exploit its natural resources. Those activities will not be hindered in areas outside the Proposal area.

11.3.3 Alteration of Aboriginal heritage and cultural values

With the destruction of the five OHPs within the disturbance area and possibly Site 252, the Kaparn and Kelamaia-Kabu(d)n Peoples and the eastern Ballardong families will no longer have access to them and therefore aspects of the heritage and cultural values associated with these OHPs and possibly Site 252 will be lost.

In the case of Site 252, the Kaparn and Kelamaia Kabu(d)n people believe that the fundamental heritage and cultural values of the area are immanent in the artefact assemblage, rather than the earth upon which the assemblage rests. If the haul road can be safely realigned away from Site 252, then clearly there will be no alteration to both the heritage and cultural values of the place. If such realignment is not feasible, then the removal of the artefacts to another location by the Aboriginal people themselves will ensure that the heritage and cultural values, as defined by the Aboriginal people, will be salvaged.

OHPs DAA ID 29178 and 29179 (J5 Rockhole 1 and J5 Rockhole 2), as noted above, are small gnamma holes in an ironstone outcrop, with no associated evidence of prehistoric Aboriginal usage and no current ethnographic associations, as they were unknown to the Kaparn and Kelamaia Kabu(d)n people before their discovery in the course of heritage surveys. Nonetheless, as potential water-sources, albeit without any evidence of human associations, they have a low level of cultural significance to the Aboriginal people concerned. The mitigating management proposals for these two OHPs have been discussed with the two Aboriginal groups concerned and will serve to preserve, in photographic and text format, a record of the discovery.

The status of OHP DAA ID 20342 is not a matter of agreement between the Kaparn and Kelamaia Kabu(d)n Peoples, on the one hand, and the Wangkayi people who recorded it as an Aboriginal site on the other. In relation to this matter, a Wangkayi elder, who had participated in the field excursion to the Bungalbin area addressed the following letter to the Registrar of Aboriginal Sites at the DAA on 4 October 2010:

> *Re: Aboriginal Site Number 20342, KY 28. I am writing to you regarding the above Aboriginal site, because I understand that I have been incorrectly listed in the Register of Aboriginal Sites as a spokesperson for it and for the area in which it is located. The Bungalbin area is the traditional country of the Sambo and Champion families, who are part of the Kelamaia Kabu(d)n and Central West Goldfields Peoples group. It is not my traditional country and I do not have rights there. I was consulted by the Champion and Sambo families about traditional stories that travel outwards from my country near Warburton Ranges. I also went to Bungalbin as a guest at the invitation of some members of those families. I had never been there before that visit. I made that clear to Mr Parker, who drove us there. My name should not be listed as a person with traditional knowledge of the Bungalbin area. If you require any information about Aboriginal sites there, you should get it from the older members of the Sambo and Champion families.*

Notwithstanding this situation, MRL is consulting one additional member of the above Wangkayi group in an endeavour to establish firmly the location of OHP 20342. Mitigating management proposals for this OHP are detailed in Section 11.4.

OHP DAA ID 18726 (Aurora Range Women’s Place) was recorded by a group of Ballardong women in the period when the Ballardong native title claim extended over the Proposal area. As noted above, ethnographic data suggest that this OHP has not been used for birthing purposes for at least two generations. With the training of Aboriginal nurses and nursing aides and the establishment of Aboriginal Medical Services, so-called “bush births” are no longer considered safe activities by Aboriginal women. The cultural values associated with such birthing practices therefore belong now in the realm of history. The removal of the OHP will therefore affect the historical cultural values rather than current values and the management/mitigation proposals outlined above, which have been accepted by the Ballardong informants, will record those historical values in detail. Residual cultural values associated with the artefact scatter within and around the cave will be retained by the Ballardong women who recorded the OHP collecting the artefacts and removing them to a place of safety.

OHP DAA ID 18732 (Helena Cave) was recorded by male members of the Ballardong Yarran and Winmar families on the basis of information from a deceased member of the former family. Initiations into the particular Dreaming story associated with the cave have not taken place there for at least two, and probably more, generations. Again, the Ballardong informants in question are satisfied that the cultural and heritage values of this former Aboriginal initiation area can be adequately dealt with as set out in the management/mitigation process outlined below.

There are seven other OHPs within the MMHARCP together with the MRL-defined cultural heritage areas that will remain undisturbed by the Proposal. In those cases, the Proposal will not result in significant alteration to their associated Aboriginal heritage and cultural values. Indirect impact on those values will be avoided by ongoing consultation with the relevant Aboriginal groups.

11.3.4 European heritage values

Access along the informal stock route and the Menzies coach road will remain open, despite passing near to the proposed J5 operation. Haul road crossings will be managed with signage as they are on the Koolyanobbing Track at Koolyanobbing and south of Aurora, MRL does not expect the Proposal to have any other impacts on European heritage values.

11.4 Proposed heritage management

11.4.1 General management approach

MRL general approach to management of heritage is outlined within the policy, plan and procedure listed in **Table 11-5**. An Aboriginal Cultural Heritage Management Plan specific to the Proposal will be prepared prior to the commencement of construction. It will be based on the proposed management outlined in this section and on community feedback received during the assessment process.

TABLE 11-5: MANAGEMENT OF HERITAGE – MRL PLANS AND PROCEDURES

Doc. No	Title	Description
MRL-EN-POL-0001	Environment and Community	Company policy in relation to the environment and communities (**Appendix 1-A**).
MRL-EN-PLN-0001	Environmental Management Plan	Outlines the systematic approach to environmental management (**Appendix 2-A**).
MRL-EN-PRO-0015	Heritage Management	Describes procedures for management of Aboriginal and European heritage (**Appendix 2A**).
In preparation	Aboriginal Cultural Heritage Management Plan (site specific)	Will provide the framework for managing remaining OHPs and other MRL-defined cultural heritage areas in proximity to the Proposal.

11.4.2 Aboriginal heritage sites (OHPs)

The objectives in the case of the following areas are to ensure that relevant legislation, being the relevant provisions of the AH Act and the EP Act are strictly observed and that the aspirations of the relevant Aboriginal groups in respect of these OHPs are, to as great an extent as possible, carried out. **Table 11-6** outlines those OHPs that will be disturbed and identifies how the disturbance will be mitigated.

TABLE 11-6: DISTURBANCE TO OHPS AND MITIGATION

OHP	DISTURBANCE LEVEL	MITIGATION
DAA ID 29178 - J5 Rockhole 1	Total	This is a small gnamma hole in an ironstone outcrop. There are no Aboriginal artefacts in association with it and therefore no evidence of former human usage. Its presence was unknown to the Aboriginal groups before discovery in the course of the field survey. The groups do not object to its disturbance, subject to appropriate Ministerial Consent pursuant to Section 18 of the AH Act being obtained. As mitigation before that disturbance and the lodgement of the Section 18 Notice in its regard, the gnamma hole will be photographed in situ and a written record of its location and nature will be made to accompany the photographic record. That record will be held by MRL, and a copy will be provided to DAA and the two Aboriginal groups.

OHP	DISTURBANCE LEVEL	MITIGATION
DAA ID 29179 – J5 Rockhole 2	Total	This is also a small gnamma hole in the same ironstone outcrop as OHP 29178. There are no Aboriginal artefacts in association with it and therefore no evidence of former human usage. Again, its presence was unknown to the Aboriginal groups before discovery in the course of the field survey. Again also, the groups do not object to its disturbance, subject to appropriate Ministerial Consent pursuant to Section 18 of the AH Act being obtained. As mitigation before that disturbance and the lodgement of the Section 18 Notice in its regard, the gnamma hole will be photographed in situ and a written record of its location and nature will made to accompany the photographic record. That record will be held by MRL, and a copy will be provided to DAA and the two Aboriginal groups.
DAA ID 20342 – KY 28	Total[3]	Once the final position of OHP 20342 has been established, it will be photographed and a written record of its mythological significance, as reported by the Wangkayi elders, will be made. This record will be held by MRL and a copy will be provided to DAA and to the surviving Wangkayi elders. A Notice pursuant to Section 18 of the AH Act will then be lodged in respect of DAA ID 20342.
DAA ID 18726 – Aurora Range Women's Place	Total	The Aboriginal Site File relating to this OHP is held by DAA under restricted access. Signed permission to view the file must be obtained from the Registered Informants. Access is also female-restricted. Female Ballardong group members gave the necessary permission to a representative of MRL. The precise location of the OHP was therefore established, both from the Aboriginal Site File and from a later field inspection by a Ballardong representative. As the disturbance to this site will be total, mitigation will comprise: Lodgement of a Notice pursuant to Section 18 of the AH Act in respect of proposed mitigation and eventual disturbance of DAA ID 18726. Archaeological test-pitting of the cave floor deposit, under the supervision of representatives of the relevant Aboriginal group, in order to extract any scientific information that may be there. Photographic recording of the cave site. Detailed written recording of its Ballardong traditions. Collection of the artefacts within and surrounding the cave by representatives of the Ballardong people and their removal to a site where they will be safe from further disturbance.

[3] Based on the approximate recorded position of the mythological site. It's position will not be precisely defined until the final custodians are consulted.

OHP	DISTURBANCE LEVEL	MITIGATION
		The record of these activities will be held by MRL. In view of the restricted nature of the Ballardong material, distribution of copies will be strictly limited to those parties approved by the Ballardong representatives.
DAA ID 18732 – Helena Cave	Total	The Aboriginal Site File relating to this OHP is also held by DAA under restricted access. Again, signed permission to view the file must be obtained from the Registered Informants but, in this case, access is male-restricted. Registered Informants granted the required permission to a representative of MRL. The precise location of the OHP was therefore established, both from the Aboriginal Site File and from a later field inspection by the Ballardong representative. As the disturbance to this site will be total, mitigation will comprise: Lodgement of an appropriate Notice pursuant to Section 18 of the AH Act in respect of the proposed mitigation and eventual site disturbance. Archaeological test-pitting of the section of the cave floor not obscured by rock-fall to ascertain whether the deposit contains any Aboriginal cultural material. In the event of such material being uncovered, detailed recording will be carried by the archaeologist and collection of the artefacts and removal to a site where they will be safe from further disturbance will be carried out by representatives of the Ballardong people. Photographic recording of the cave site will be carried out. Detailed written recording of its Ballardong traditions will be made. The record of these activities will be held by MRL. In view of the restricted nature of the Ballardong material, distribution of copies will be strictly limited to those parties approved by the Ballardong representatives.

11.4.3 Aboriginal heritage sites (MRL-defined cultural heritage areas)

Of the six MRL-defined cultural heritage areas, only one occurs within the disturbance area, namely Site 252. The remaining cultural heritage areas occur outside the disturbance area but within the vicinity of the Proposal. **Table 11-8** details management plans for these areas. Site Recording forms have been submitted to DAA for all six areas.

As was the case with the OHPs, outcomes/objectives in the case of the following areas are to ensure that relevant legislation, being the relevant provisions of the AH Act and the EP Act are strictly observed and that the aspirations of the relevant Aboriginal groups in respect of the following areas are, to as great an extent as possible, carried out.

TABLE 11-7: MANAGEMENT OF OHPS NOT SUBJECT TO DISTURBANCE

OHP	MANAGEMENT
DAA ID 18731 – Helena Aurora Range Engraving	As shown on **Figure 11-2**, no disturbance to this site will occur. Nonetheless, it was visited by MRL representatives and a representative of the Ballardong family whose members originally recorded it with the DAA. It was discovered that the single engraved boulder had been removed by person(s) unknown and was no longer in the site.
DAA ID 20336 – KY19	Although the disturbance area of this OHP held in the Aboriginal Site File at DAA shows it extending into the proposed development area, it has been established that OHP 20336 will not in fact be impacted by the Proposal, based on an Aboriginal Heritage Survey conducted by archaeologist John Cecchi and representatives of the Kaparn and Kalamaia Kabu(d)n groups in October 2014 that mapped the exact boundary of the OHP within the broad extent previously defined by the DAA. It is clear from that survey that the features of OHP20336/KY 19, which are the rockhole and significant artefact scatter, will not be impacted by the Proposal. Management in this case will involve the following steps: The boundaries of OHP20336 will be marked clearly on all MRL Proposal maps and it will be delimited as a "No Go Area". OHP20336 will be off limits to all Company personnel and contractors working on the Proposal; this rule will be strictly enforced. The above "off limits" rule will be conveyed to all Company personnel and contractors at the time of Proposal induction and at start-up meetings.

TABLE 11-8: MANAGEMENT OF MRL-DEFINED CULTURAL HERITAGE AREAS

AREA	DISTURBANCE LEVEL	MANAGEMENT
Site 252 Artefact scatter	Indeterminate	DAA Site Recording Form submitted. As currently planned, the Bungalbin East/J5 Haul Road would pass through this artefact scatter and cause total disturbance. The preliminary (and preferred) management option is for the haul road to be realigned slightly to carry it clear of the site and thereby avoid all and any disturbance. However, if gradients and hazardous bends render this preliminary management plan impractical, then that will be taken as a triggering action for the following mitigating actions: • A Notice pursuant to Section 18 of the AH Act will be lodged in respect of the disturbance of the site and the following proposals. • Photographic recording of the site. • Collection of the artefacts within the site by representatives of the Kaparn and Kalamaia Kabu(d)n people who identified the site and their removal to an area where they will be safe from further disturbance.

AREA	DISTURBANCE LEVEL	MANAGEMENT
Site 270 Scarred tree	Nil disturbance	DAA Site Recording Form submitted. Management in this case will involve the following steps: • The boundaries of Site 270 will be marked clearly on all MRL Proposal maps and it will be delimited as a “No Go Area”. • Site 270 will be off limits to all Company personnel and contractors working on the Proposal; this rule will be strictly enforced. • The above “off limits” rule will be conveyed to all Company personnel and contractors at Proposal induction and at start-up meetings.
Damon’s Scar Tree	Nil disturbance	DAA Site Recording Form submitted. Management in this case will involve the following steps: • The boundaries of the site will be marked clearly on all MRL Proposal maps and it will be delimited as a “No Go Area”. • The site will be off limits to all Company personnel and contractors working on the Proposal; this rule will be strictly enforced. • The above “off limits” rule will be conveyed to all Company personnel and contractors at Proposal induction and at start-up meetings.
Damon’s Rockholes	Nil disturbance	DAA Site Recording Form submitted. Management in this case will involve the following steps: • The boundaries of the site will be marked clearly on all MRL Proposal maps and it will be delimited as a “No Go Area”. • The site will be off limits to all Company personnel and contractors working on the Proposal; this rule will be strictly enforced. • The above “off limits” rule will be conveyed to all Company personnel and contractors at Proposal induction and at start-up meetings.
Damon’s Quarry 2	Nil disturbance	DAA Site Recording Form submitted. Management in this case will involve the following steps: • The boundaries of the site will be marked clearly on all MRL Proposal maps and it will be delimited as a “No Go Area”. • The site will be off limits to all Company personnel and contractors working on the Proposal; this rule will be strictly enforced. • The above “off limits” rule will be conveyed to all Company personnel and contractors at Proposal induction and at start-up meetings.

AREA	DISTURBANCE LEVEL	MANAGEMENT
Damon's Quarry 1	Nil disturbance	DAA Site Recording Form submitted. Management in this case will involve the following steps. • The boundaries of the site will be marked clearly on all MRL Proposal maps and it will be delimited as a "No Go Area". • The site will be off limits to all Company personnel and contractors working on the Proposal; this rule will be strictly enforced. • The above "off limits" rule will be conveyed to all Company personnel and contractors at Proposal induction and at start-up meetings.

Routine heritage controls will be implemented to manage the OHPs and MRL-defined cultural heritage areas. These controls address key aspects of the Proposal including clearing and earthworks and include:

- limiting disturbance to areas that have been subject of heritage clearance after being inspected in detail by survey teams from both the Kelamaia Kabu(d)n and Kaparn groups
- issuing of Substantial Disturbance Permits which clearly delineate approved areas for the ground disturbance and outline heritage restrictions
- use of Aboriginal monitors from the Kaparn and Kelamaia Kabu(d)n in highly sensitive areas or as required by Ministerial Consent – highly sensitive areas being defined as the near vicinity of OHPs and MRL-defined cultural heritage areas
- demarcation and signage of heritage places and sites
- compulsory inductions for all mine personnel prior to commencing work and training in relation to cultural heritage obligations
- cultural awareness training for mine personnel to improve their understanding of cultural heritage values within the area; such training to be carried out by members of the Aboriginal groups whose traditional lands encompassed the Proposal area.

11.4.4 Aboriginal heritage sites (rock shelters)

There are twenty one rock shelters (see **Figure 11-3**) with the potential to contain evidence of human usage although they do not contain any surface Aboriginal cultural material. DAA Site recording forms have not yet been submitted for these twenty one rock shelters as, at this stage and before further investigation, it is not known if they contain any sub-surface Aboriginal cultural material.

Following receipt by MRL of Ministerial Consent pursuant to Section 18 of the AH Act for the Proposal, archaeological test-pitting of the rock shelters numbered 1-21 will be carried out under the supervision of the relevant Aboriginal groups. If it is established that there is no evidence of former human usage in the form of Aboriginal cultural material, then no further action is required. In the event of Aboriginal cultural or skeletal material being uncovered, then procedures as laid out in the management plan for Aboriginal cultural sites discovered in the course of Proposal execution will be followed.

11.4.5 Cultural uses

Access for cultural uses will be limited during the construction and operation of the mine but access to other parts of the MMHARCP will remain. Some additional survey work is proposed which will involve Aboriginal people.

11.4.6 Unexpected discoveries of heritage materials

It has been stated above that, based on the number of Aboriginal heritage surveys which have been undertaken throughout the HAR, it is very unlikely that there are further cultural sites that have not been identified. Nonetheless, it cannot be stated with absolute certainty that execution of the Proposal will not lead to further discovery of such sites. Clearly, it is impossible for heritage survey teams to see what is beneath the ground surface. This section of this document therefore deals with actions to be taken in the event of such further discovery.

Two types of sub-surface material – skeletal material and Aboriginal cultural materials - may be encountered in the course of ground disturbance, each type requiring immediate and specific action, as follows. In the event of verified, or possible, human skeletal material being discovered, that constitutes a triggering event and the following well-established chain of events must be followed:

- The Aboriginal monitor(s) or worker(s) making the discovery should immediately notify the on-site Manager/Overseer. If the discovery is made by a worker, they should notify the Aboriginal monitors and request their attendance at the discovery site.
- The Manager/Overseer should immediately order all earthmoving or other ground disturbing activity in the near vicinity of the discovery to cease. For the purposes of this document, “near vicinity” should be taken as a circle of 20 m diameter centred upon the skeletal material. Outside that designated area, work can proceed. The Aboriginal monitors on hand should supervise the implementation of this aspect of the management plan.
- The Manager/Overseer should notify the Site Supervisor or other senior MRL person on site.
- The Site Supervisor or other senior person should then notify the WA Police at the nearest Police Station and request them to attend on site. The telephone number for Southern Cross Police Station is (08) 9081 2100.
- The Site Supervisor or other senior person should also notify the Registrar of Aboriginal Sites at the Department of Aboriginal Affairs. The Registrar should be contacted on 1300 651 077.
- The Police will investigate the remains as soon as possible. In the interim, the “stop-work” order should remain in force, under the supervision of the Aboriginal monitors. The Police will identify whether the remains are indeed human and, if of prehistoric Aboriginal origin, not a matter for their further involvement.
- Upon receiving such notification, the Registrar will consult with and seek the involvement of relevant Aboriginal people. As the relevant persons will be participating in the monitoring programme, this stage of the process is shortened and facilitated.
- Further action will be dependent upon the outcomes of the consultative process noted above, but could include exhumation of the human remains and reburial in a place selected by the Aboriginal people.

It is noted that discovery of skeletal material in the rocky sectors of the Proposal area is not likely, but that such discoveries are possible in the rock shelters that will be investigated in accordance with the management provisions outlined in **Table 11-8**.

With regard to Aboriginal cultural materials, the Ministerial Consent pursuant to Section 18 of the AH Act will contain provisions to deal with discovery of this type of material. If the discovery is made before that Consent has been issued, then that constitutes a triggering event and the following chain of events must be followed:

- The monitor(s) or worker(s) making the discovery should immediately notify the on-site Manager/Overseer. If the discovery is made by a worker, they should notify the monitors and request their attendance at the discovery site.
- The on-site Manager/Overseer should immediately order all earthmoving or other ground disturbing activity in the near vicinity of the discovery to cease. For the purposes of this document, "near vicinity" should be taken as a circle of ten metres (10 m) diameter centred upon the discovery site. Outside that designated area, work can proceed.
- The site Manager/Overseer should notify the Site Supervisor or other senior MRL person on site and notify him or her of the discovery.
- The Site Supervisor should arrange attendance on site by an archaeologist. The archaeologist will attend on-site, inspect and assess the significance of the material and consult with the monitors of the day regarding the discovery. Further action will depend on the outcomes of that consultation, but could include a request to Department of Aboriginal Affairs to attend on-site to inspect the material or an agreement with the monitors that the material does not constitute an Aboriginal site and that work can proceed.

11.4.7 Overview of approach to heritage management

The overall approach to heritage management with triggers and contingency actions is outlined in **Table 11-9**.

TABLE 11-9: OVERVIEW OF HERITAGE MANAGEMENT

Heritage item	Management and Monitoring	Trigger	Contingency actions
Other Heritage Places (OHPs)	No disturbance unless approval received under the AH Act.	Unauthorised disturbance.	Cease disturbance, report to DAA and Traditional Owners.
MRL-defined cultural heritage areas	No disturbance unless approval received under the AH Act.	Unauthorised disturbance.	Cease disturbance, report to DAA and Traditional Owners.
Rock shelters	No disturbance until archaeological test-pitting of the rock shelters and subsequent approvals received, if required.	Unauthorised disturbance.	Cease disturbance, report to DAA and Traditional Owners.
Cultural uses	Allow access where safe.	-	-
Unexpected discoveries	Archaeological investigation.	Discovery.	Report to DAA and Traditional Owners, meet requirements of AH Act.

11.5 Residual impact

The Proposal will have a residual impact on Aboriginal heritage, despite efforts to avoid or minimise impacts as outlined in the preceding section, to the extent that five OHPs and potentially Site 252 will be disturbed and ultimately lost.

Some restrictions to access will be required during the construction and operation of the mine. However, the ongoing heritage surveys carried out with the Aboriginal groups have served to strengthen and extend the cultural and heritage links with the area. This is an expression of retaining customary knowledge, use and activities, rather than simply protecting "sites".

The aim of the management and mitigation procedures outlined above is towards strengthening and extending the heritage link with country in general, even in cases where an individual "site" will be destroyed. By involving the Aboriginal groups in those heritage surveys and in the ongoing management of their heritage and culture in the Proposal area, the cultural link with the land in the MMHARCP will likely, in fact, be strengthened rather than adversely affected.

11.6 Predicted outcome

The EPA objective for heritage is to ensure that historical and cultural associations, and natural heritage, are not adversely affected. The EPA objective is complemented by EPA Guidance Statement 41 which requires consideration of the Proposal in relation to resulting changes to physical and biological attributes of the environment that may impact on the heritage significance of those attributes to Aboriginal people.

The rockholes at J5 can be linked to the physical environment by virtue of the fact that they provide a potential source of water. However, the removal of these rock holes is not considered significant. Other than these two OHPs there is no heritage significance associated with the physical and biological attributes of the environment in the area.

The impact of the Proposal on Aboriginal heritage can therefore be adequately managed under the provisions of the AH Act and implementation of the Aboriginal Cultural Heritage Management Plan. In this regard, all DAA OHPs, together with Site 252, will be the subject of a s18 Notice in relation to the Proposal.

It should be noted that revised boundaries of OHPs KY19 and Helena-Aurora Range Engraving will be formally assessed as part of the s18 Notice. The boundaries of these sites were revised by the Kaparn and Kelamaia-Kabu(d)n Peoples during surveys by Cecchi (Cecchi, 2014c; 2014d), Mathieu (Mathieu, 2014b) and O'Connor (2012).

It is possible that the Ministerial Consent will stipulate conditions with regard to taking of the five OHPs and possibly Site 252. Similar Ministerial Consents covering similar OHPs in the past have required artefact salvage before the taking of the OHP. In this way the Kaparn and Kelamaia-Kabu(d)n Peoples will save as much cultural material as is possible.

Extensive consultation regarding the irrevocable and irreversible nature of the disturbance to the relevant OHPs has occurred with the Kaparn and Kelamaia-Kabu(d)n Peoples during Aboriginal Heritage Surveys and other interactions. At no time during these discussions have the Kaparn and Kelamaia-Kabu(d)n Peoples expressed a desire for the Proposal not to proceed.

All due consideration will be given to the Kaparn and Kelamaia-Kabu(d)n Peoples utilising OHPs and MRL-defined cultural areas within the Proposal if they are not disturbed.

MRL and the Kaparn and Kelamaia-Kabu(d)n Peoples have always had a good working relationship based on mutual trust and respect. This will mean that the Aboriginal Cultural Heritage Management Plan will be discussed with the Kaparn and Kelamaia-Kabu(d)n Peoples and their comments and views will be taken into consideration.

For the reasons outlined above, the EPA objective for heritage can be met in respect of the Proposal.

12. REHABILITATION AND DECOMMISSIONING

12.1 EPA objective, policies and guidelines

The EPA objective for rehabilitation and decommissioning as an integrating factor is:

- to ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.

The policy and guidance documents referenced as part of the impact assessment are provided in **Table 12-1**.

TABLE 12-1: LEGISLATION, POLICIES AND GUIDANCE CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Department of Mines and Petroleum and Environmental Protection Authority (2015). Guidelines for Preparing Mine Closure Plans. Perth, Western Australia.	Outlines the DMP's and EPA's requirements for planning mine closure, decommissioning and rehabilitation in order to meet the DMP and EPA's objectives.	The Rehabilitation and Mine Closure Plan (RMCP) (**Appendix 12-D**) has been prepared in accordance with this guideline where available at this time.
Environmental Protection Authority (2006). Guidance Statement No. 6: Rehabilitation of Terrestrial Ecosystems. Perth, Western Australia.	Focuses on effective use of completion criteria to measure biodiversity in rehabilitation projects. Aims specifically at increasing the quality, uniformity, and efficiency of standards and processes for rehabilitation of native vegetation in Western Australia and to allow more effective monitoring and auditing of outcomes.	The RMCP has been prepared in accordance with this guideline, particularly in regard to completion criteria.
Environmental Protection Authority (2013) Environmental Protection Bulletin No. 19. EPA involvement in mine closure.	Outlines the roles of the DMP and the EPA in mine closure and explains the circumstances when the EPA considers mine closure as a key integrating factor will assess mine closure.	Mine closure has been included as a key integrating factor in this assessment.
Non- EPA Policy and Guidelines		
Department of Industry and Resources (1997). Safety Bund Walls around Abandoned Open Pit Mines – Guideline.	Identifies the requirements for placement of abandonment bunds around pit voids to prevent inadvertent access.	Referenced in Section 8 of the RMCP and **Section 12.3** of the PER.

12.2 Planning rehabilitation and decommissioning

12.2.1 Context

Implementation of the Proposal will result in localised but substantial changes to the northern section of the HAR. Three waste rock landforms and three open pit voids will be created and will become permanent features of the landscape.

The Proposal cannot be implemented without these changes; however, given the location of the Proposal within the MMHARCP, the EPA has identified rehabilitation and decommissioning as an “integrating factor” – a factor likely to be related to one or more ‘environmental’ factors, such as flora and vegetation, or landforms (Environmental Protection Authority, 2015a).

MRL recognises and accepts that if the Proposal is implemented the standard of rehabilitation and decommissioning works completed will have an impact on the future value of the area for conservation and recreation.

The EPA (2015a) noted the following potential environmental impacts and risks associated with rehabilitation and decommissioning of the Proposal:

- Permanent alteration of the landform(s) and associated natural hydrology, flora and fauna
- Acid and/or metalliferous drainage (AMD)
- Unsuccessful rehabilitation of flora and vegetation in cleared/developed areas
- Impact on soils from compaction and erosion
- Impediment of rehabilitation success due to the spread of weeds
- Other threatening processes (i.e. trampling by livestock, increased risk of fire) impeding rehabilitation process

Permanent alteration of the landforms is inevitable in the event of implementation of the Proposal. The extent to which other potential impacts can be managed will determine the final land use once mining is complete. Failure to manage these impacts will result in landforms requiring long term maintenance and could lead to degradation of adjoining undisturbed areas.

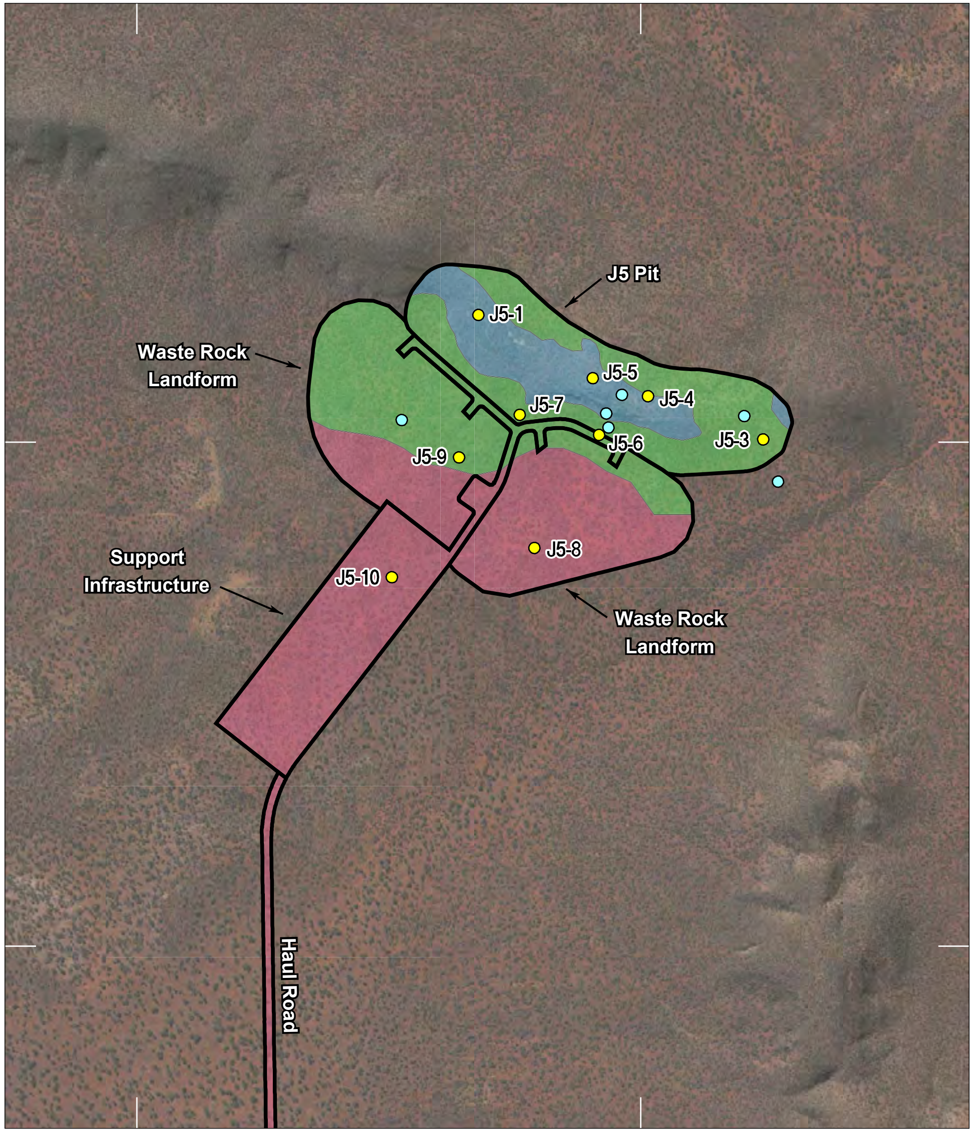
Successful rehabilitation and closure will result in landforms supporting comparable vegetation to that existing in undisturbed areas and that are of potential scientific and recreational interest.

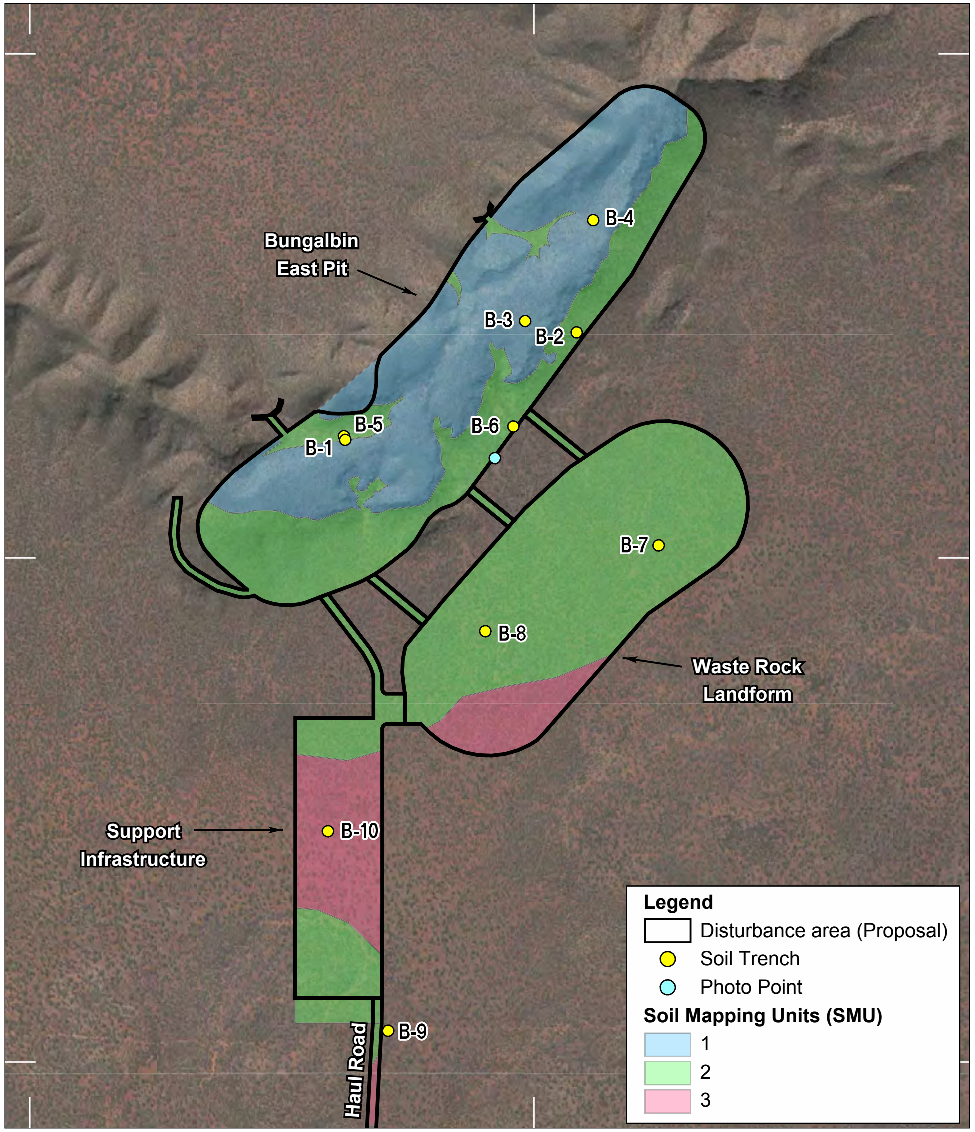
12.2.2 Soil physical and chemical characteristics

The soils throughout the Proposal Area were mapped at a local-scale by Soilwater Consultants (**Appendix 12-A**). This work identified that there are three soil-landscape units or Soil Mapping Units (SMU) (**Figure 12-1**) within the J5 and BE Mine Areas:

- SMU 1: Skeletal Gravels
- SMU 2: Shallow-Deep Gravels
- SMU 3: Deep Alluvial Clays

The distribution of these soils exhibits strong geomorphic and topographic controls such that the skeletal gravels only occur on the ridge line and upper slope positions, whilst the shallow-deep gravels, which represent the eroded fraction of the skeletal gravels, occurs along the mid-to lower-slope positions. The deep alluvial clays are restricted to the flat, low-lying plain surrounding the BIF ridges.





Notes
Infrastructure supplied by Mineral Resources(July 2016)
Soils mapping supplied by SoilWater Group (Aug 2016)

0 250 500m
Scale 1:30,000
MGA94 (Zone 50)
CAD Ref: g2378_J5_BE_PER_C12_F12_10
Date: July 2016 | Rev: A | A4

Author: Mineral Resources
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

SOIL MAPPING UNITS

Figure: **12-1**

The gravely soils of SMU 1 and 2 exhibit optimal physical and chemical properties for both material handling and future rehabilitation. These materials are structurally stable, non-dispersive and generally non-sodic, and have good rock armouring capabilities. In contrast, the clayey soils of SMU 3 are dispersive, sodic and highly erodible. None of the soils exhibit chemical limitations to vegetation growth.

Based on the above properties, all gravelly SMU 1 and 2 soils are considered optimal for use in rehabilitation and will be excavated and stockpiled separately to the clayey soils of SMU 3. The expected volumes of each soil type to be stripped during mining are provided in **Table 12-2**.

There is appreciable volume of the gravelly soils across both the J5 and BE Deposits, to the extent that a surface layer of gravel to a depth of 45cm at J5 and 80cm at BE can be achieved, based on the proposed waste rock landform design,. The surface of the WRLs will be stable and resistant to erosion where a cover depth of 45cm of gravelly soils is achieved.

TABLE 12-2: SUMMARY OF SOIL RESOURCES AT J5 AND BUNGALBIN EAST

Soil type	J5		Bungalbin East	
	Topsoil (m^3)	Subsoil (m^3)	Topsoil (m^3)	Subsoil (m^3)
SMU 1	12,200	0	45,300	0
SMU 2	80,300	321,200	165,500	662,000
SMU 3	89,900	194,800	35,300	49,600
TOTAL	**182,400**	**516,000**	**246,100**	**711,600**

Given the dispersive and erodible properties of the SMU 3 clays, this material will only be used on flay surfaces within the WRLs, such as the top and any berms or benches that are included in the design.

12.2.3 Waste rock characterisation

Acid mine drainage (AMD)

An analysis of the geochemical characteristics of the waste rock within both the J5 and Bungalbin East Deposits was undertaken by Soilwater Consultants (**Appendix 12-B**).

For both deposits, the proposed mine pits will be above the water table and thus will principally involve mining the weathered or regolith profile. This regolith profile has been extensively weathered or leached since the Tertiary period, and any sulphides that may have been present in the original parent bedrock is likely to have been oxidised. This weathering scenario has been confirmed at the nearby J4 deposit, and elsewhere in the region such as Cliffs' Koolyanobbing, Mt Jackson and Windarling Iron ore deposits.

The risk of intersecting appreciable Potential Acid Forming (PAF) or sulphidic materials is therefore significantly reduced as a result of weathering at the J5 and BE deposits (i.e. low risk). The waste rock materials with elevated Total Sulfur (S) values, and thus potentially PAF, are generally restricted to below the mine pit, being associated with the fresh rock and / or below the water table (**Appendix 12-B**).

Elevated Total S values (i.e. > 0.3%) were generally associated with the siltstone and magnetite lithological units, which at the J5 deposit occur mostly below the mine pit floor. At Bungalbin East, 95 % of all waste rock to be mined is classified as a jasperlite BIF, with the remaining 5 % classified as laterite, with no siltstone and magnetite BIF lithological units recorded in the waste material.

A material balance of the ore and waste rock to be mined at the J5 and BE deposits, including the PAF materials, is provided in **Table 12-3**.

Using the above volumes, an Acid Base Account (ABA) was undertaken to establish the potential risk from AMD. As no actual static geochemical data was available, a risk-based approach, using a range of scenarios, was used to establish the likelihood that ARD would be an issue. The ABA for the J5 and Bungalbin East deposits is provided in **Table 12-4** and **Table 12-5** respectively.

The ABA shows that because of the low PAF volume potentially disturbed in both the J5 and BE deposits, there is therefore a large volume of material that is not acid forming (NAF). For this reason, there is always an appreciable excess of alkalinity in the waste material and thus the potential for AMD is considered low.

Even if the Total S content for all of the PAF material was equivalent to the maximum Total S content measured to date (i.e. 2.71% for J5 and 0.66% for Bungalbin East), the sheer volume of NAF material, having negligible acid neutralising capacity (ANC) (i.e. 5 kg H2SO4/t), would still result in a significant excess of alkalinity for the J5 and Bungalbin East.

TABLE 12-3: TOTAL VOLUME OF MATERIALS TO BE MINED

	J5 (m^3)	**Bungalbin East (m^3)**
Total pit volume	8,596,000	69,545,000
Ore material	5,081,000	37,727,000
Waste rock material	3,515,000	31,818,000
PAF volume[1] (of total material to be mined)	279,400	4,625,400

[1] Based on proportion of the various siltstone and magnetite BIF lithological units recorded in the geological drilling data (3.3 % for J5 and 12.3 % for Bungalbin East).

TABLE 12-4: ACID BASE ACCOUNT FOR J5

Potential Maximum Acid Generation (MPA)							
Total S (%)	0.3	0.5	1.0	1.5	2.0	3.0	5.0
MPA (kg H_2SO_4)	9.18	15.3	30.6	45.9	61.2	91.8	153
PAF (Mt H_2SO_4)[2]	5.64	9.40	18.81	28.21	37.61	56.42	94.04
Potential Buffering Capacity							
ANC (kg H_2SO_4/t)	5	10	20	30	50	100	150
Buffering (Mt H_2SO_4)[3]	714.12	1,428.24	2,856.48	4,284.73	7,141.21	14,282.42	2,744.53

[1] Based on PAF volume specified in **Table 12-3**

[2] Determined by multiplying the ANC value with the volume of NAF from **Table 12-3** (NAF = Total volume – PAF volume).

TABLE 12-5: ACID BASE ACCOUNT FOR BUNGALBIN EAST

Potential Maximum Acid Generation (MPA)							
Total S (%)	0.3	0.5	1.0	1.5	2.0	3.0	5.0
MPA (kg H_2SO_4)	9.18	15.3	30.6	45.9	61.2	91.8	153
PAF (Mt H_2SO_4)[1]	93.41	155.69	311.38	467.07	622.76	934.14	1,556.90
Potential Buffering Capacity							
ANC (kg H_2SO_4/t)	5	10	20	30	50	100	150
Buffering (Mt H_2SO_4)[2]	714.12	1,428.24	2,856.48	4,284.73	7,141.21	14,282.42	21,423.63

[1] Based on PAF volume specified in **Table 12-3**
[2] Determined by multiplying the ANC value with the volume of NAF from **Table 12-3** (NAF = Total volume – PAF volume).

Even if the volume of PAF increased by 100% of the volumes reported in Table 12-3, and still assuming maximum Total S content and negligible ANC, there would still be an excess of alkalinity. At the nearby J4 deposit (which has similar lithological units), the ANC content is generally around 10 kg H_2SO_4/t (still considered low). At this ANC value, the volume of NAF would still be larger than the potential acidity assuming all PAF had a Total S content of 5%. The risk of AMD occurring as a result of the Proposal is therefore low.

Given the large excess of alkalinity that is likely to occur, it is considered that co-mingling of the waste rock materials will be sufficient to management the PAF materials and ensure no AMD results.

During the early stages of Proposal development, a drilling program for improved resource definition will be undertaken. At this stage, additional sampling and analysis of waste rock will be completed to refine the analysis.

Metalliferous drainage

As the orebody at both the J5 and Bungalbin East deposits occurs within the extensively weathered oxide profile, the potential for metalliferous drainage to occur is significantly reduced. The residual metals and metalloids present in the oxide kaolinitic profiles are likely to be immobile under atmospheric conditions as previously intense weathering would have removed any mobile forms, with the remaining metals likely to be strongly held within the crystal mineral structure through isomorphic substitution. This immobility of metals and metalloids was observed in the nearby J4 deposit, which exhibits similar lithological unity and geochemical conditions.

Other problematic materials

All material below the lateritic caprock is considered waste rock. An assessment of the Aluminium (Al) / Silica (Si) ratio clearly shows that the regolith materials are dominated by kaolinite, with minor smectite zones. The regolith material above the water table is expected to be sodic and exhibit variable salinity, with values from <40 mS/m (i.e. non-saline) for highly weathered areas to >200 mS/m (i.e. extremely saline) in poorly weathered smectitic zones.

Given the likely level of sodicity, all regolith waste rock is expected to be dispersive and highly erodible, and thus should not be used anywhere near the surface of the WRL.

12.2.4 Groundwater

Due to restrictions over access to the Proposal area, no field investigations of groundwater have been conducted; however, a review of groundwater levels was commissioned to assess and interpret the available groundwater data (see **Section 9** and **Appendix 9-B**). The review concluded that groundwater levels at J5 and Bungalbin East are likely to be about 410 mAHD and 420 mAHD, respectively, except beneath the BIF ridges where they are likely to be at a higher elevation.

Where BIF ridges occur, groundwater mounds are created by a relatively high rate of infiltration and recharge through the goethite– hematite rocks that form the deposits, and the low permeability of the mafic country rocks which adjoin the BIF ridges. On this basis, it is estimated that the height of the groundwater mound beneath the proposed pit areas at J5 and Bungalbin East is estimated to be 10 m and 30 m above the regional water level, respectively. This places the water level elevation in proximity to the proposed pit areas at about 420 mAHD and 450 mAHD at J5 and Bungalbin East, respectively.

MRL will confirm the groundwater levels in the early stages of mine development. Regardless of the final groundwater levels, mining will not progress below the 3 m buffer applied to the pre-mining water table.

12.2.5 Existing rehabilitation practices and outcomes in similar environments

MRL commissioned Talis/Eco Logical Australia Pty Ltd (ELA) to undertake a literature review and provide evidence of successful best practice mining rehabilitation procedures, including a review of learnings from the rehabilitation at other banded iron formation environments in the Yilgarn Craton. A copy of the report is attached (**Appendix 12-C**).

From the limited information available to review it appears that sound progress has been made in rehabilitation of some mining projects on BIF ranges (**Table 12-6**). WRL rehabilitation is progressing well towards completion criteria on at least two sites. Some success has been achieved in translocating threatened flora, through introduction of seed rather than planting of tubestock.

Other sites that were reviewed, but for which limited evidence of progress towards rehabilitation and the achievement of completion criteria include:

- Carina and J4 (MRL)
- Koolyanobbing Group, including Mt Jackson Range (Cliffs Asia Pacific Iron Ore Pty Ltd)
- Jack Hills (Crosslands Resources Pty Ltd)
- Karara – Blue Hills (Karara Mining Ltd)

With regard to Carina there has been substantial progress of construction of the final WRL since the time of the review. Similarly, progressive rehabilitation is being undertaken at J4 with the construction of the final WRL progressing in parallel with mining operations.

With regard to Karara-Blue Hills, it is understood that at least some WRL rehabilitation has been completed but the details could not be confirmed at this time. MRL is aware of some very successful rehabilitation in the Mt Jackson Range e.g. Jackson 2/3 deposits.

Talis/ELA also looked at rehabilitation success elsewhere in Australia (**Appendix 12-C**). The information is of limited relevance to the Proposal, but the trend towards construction of mesa-like waste rock landforms, with high slope angles near the crest and low slope angles at the base, is noted.

TABLE 12-6: REHABILITATION PROGRESS AT MINES ON YILGARN BIF

Operation	Rehabilitation Progress
Tallering Peak (Mt Gibson Mining)	• About half of the waste rock landforms are at an advanced stage of rehabilitation and are meeting or are close to meeting completion criteria. • The remainder of the waste rock landforms have undergone rehabilitation earthworks but have not yet been seeded. • Management of feral goats has been necessary.
Extension Hill (Mt Gibson Mining)	• Limited broad scale rehabilitation undertaken to date. • Success has been achieved with translocations of the threatened *Darwinia masonii* and establishment from the seed bank has also been achieved.
Windarling (Cliffs Natural Resources)	• Translocation of the threatened *Ricinocarpos brevis* has been attempted. Success has been achieved using direct seeding. Use of greenhouse tubestock was not successful. • Some success in establishing the threatened *Tetratheca paynterae* subsp. *paynterae* through placement of seeds in rock crevices.
Blue Hills and Koolanooka (Sinosteel Midwest Corporation)	• Approximately 26 ha of rehabilitation at Koolanooka is progressing towards achieving competition criteria or the defined post-mining land use.

A detailed review of rehabilitation practices typically implemented within Yilgarn BIF ranges was previously undertaken by Soilwater Consultants (2009). This review, commissioned by Cliffs Asia Pacific Iron Ore Pty Ltd, and peer-reviewed by Keith Lindbeck and Associates (2009), critiqued the rehabilitation practices currently employed across the industry and more importantly identified the knowledge gaps that were limiting future successful rehabilitation of mining operations.

The key limitations to rehabilitation success were identified as:

- lack of knowledge of soil resources available at a site, and in particular the carrying capacity of the materials or their ability to support rehabilitation
- lack of survey control during waste landform construction
- lack of understanding as to the parameters affecting rehabilitation success
- inadequate or undefined rehabilitation targets.

The review included specific recommendations to address each of the above limitations. Under advice from Soilwater Consultants, MRL have implemented the recommendations in relation to its operations, including the Proposal.

12.3 Proposed management of rehabilitation and decommissioning

A Rehabilitation and Mine Closure Plan (RMCP) has been prepared (**Appendix 12-D**) in accordance with the available guidance prepared by EPA (2006) and DMP/EPA (2015) (**Appendix 12-D**).

The RMCP outlines MRL's approach to rehabilitation of the Proposal. The RMCP will form the basis for a more detailed version to be submitted to the DMP for assessment under the *Mining Act 1978*, and reviewed and updated through the life of the Proposal.

The RMCP recognises the four domains. The proposed approach to be taken in each domain is outlined in **Table 12-7**.

TABLE 12-7: PROPOSED APPROACH TO REHABILITATION IN EACH OF FOUR DOMAINS

Domain	Proposed Rehabilitation Approach
Open pits (J5 and BE)	• Three open pits - J5 and Bungalbin East (north and south nodes). • South node of Bungalbin East open pit to be backfilled to the level of the eastern crest (see **Figure 12-2**). Backfill to be topsoiled and revegetated. • Potential for the base of the other pits to also be rehabilitated through placement of topsoil and revegetation. • Abandonments bunds required to prevent inadvertent access
Waste rock landforms (J5 and BE)	• Three waste rock landforms (WRLs) – two at J5 and one at Bungalbin East. • Construction of three 10 m lifts battered out to three different angles but forming a continuous concave slope (30 m total landform height). • Batter slopes of 20° at the top decreasing to 15° at the base. • Overall WRL slope angle = 17.5°. • Slope is contour-ripped to provide surface roughness and decrease down-slope rainfall runoff. • Top of WRL 5° back-sloping away from slope crest and rock armoured to prevent erosion • Option for alternative slope angles if desired. • Soil profile constructed as per **Section 12.3.2**.
Supporting infrastructure (J5 and BE)	• Removal of all buildings and structures. • Alleviation of compaction, addition of topsoil and subsoil, revegetation.
Haul roads and linear infrastructure	• Removal or partial removal of haul roads, depending on future access requirements. • Topsoil replacement and rehabilitation.

12.3.1 Soil management

MRL's approach to soil management is outlined in the Land Clearing Procedure (MRL-EN-PRO-0004) (**Appendix 2-A**). The principles involve:

- Soil assessment and determination of stripping depths for soil and subsoil based on physical and chemical characteristics, and rehabilitation requirements.
- Recovered topsoil to be stockpiled to maximum height of 2 m to preserve the soil physical/chemical properties and seed bank.
- Subsoil, if recovered, can be stockpiled to a height of 4 m.

A site-specific plan and procedures will be produced to address soil management for the Proposal prior to the commencement of mining.

FIGURE 12-2: REHABILITATION OF J5 AND BUNGALBIN EAST

12.3.1 Open pit voids – abandonment bunds

MRL has consulted with the Environment and Geotechnical divisions of DMP regarding the positioning of abandonment bunds. Abandonment bunds will be constructed at the inside edge of the Proposal disturbance area to prevent inadvertent public access to open pit workings. MRL has not had the opportunity to conduct the detailed geotechnical drilling that would normally be undertaken prior to resource development. As such, a conservative and staged approach to geotechnical stability has been undertaken. Immediately following approvals, MRL will conduct the necessary detailed geotechnical drilling to confirm how close mining can safely approach the abandonment bunds without creating potentially unstable rock mass now or into the long term future.

In the interim, while this detailed information is being analysed, MRL will ensure that all mining will be stood back from the edge of the Proposal disturbance area and that any interim pit walls will be designed at very conservative angles. The stand back distances, pit wall angles and pit designs will be agreed with sign off from consultant geotechnical engineers and managed under DMP's Project Management Plan and Mining Proposal approval processes for both the interim pit designs and the final pit designs. Mining will only progress closer to the abandonment bunds once the necessary geotechnical work confirms the long term stability of the rock mass to DMP's satisfaction.

12.3.2 Waste rock landforms and backfilled void - reconstructed soil profiles

The proposed soil profile for the WRLs and the backfilled pit at Bungalbin East will be constructed as follows:

- Unfavourable waste rock and soil will be placed toward the centre of the landform, and will be covered by more favourable rehabilitation materials.
- A minimum of 2 m of favourable waste rock (i.e. material from below the Tertiary surface that has been partially weathered and has an earthy fabric) will be reconstructed over the surface of the landform.
- Any subsoils sourced from SMU 3 will be placed on the flat (upper) surface of the landform.
- Gravelly soils sourced from SMU 1 and SMU 2 will be placed as a cover over all other materials, to a depth of at least 0.45 m at J5 and 0.8 m at Bungalbin East.
- Contour ripping of the sloped surfaces will occur to 0.4 m depth to ensure a defined crest/trough rip line system.
- On flat surfaces (i.e. the top of the landform) ripping will occur only to 0.1 m to achieve slight heterogeneity in the surface profile (it is more of a scarification of the surface rather than ripping). Deeper ripping (i.e. > 0.1 m) is not required as these 'flat' surfaces will not erode, and the deeper waste rock material should not be brought to the surface.
- Woody debris will be spread to reduce erosion, provide fauna habitat and return organic matter to the system.
- Topsoil will be applied from the corresponding rehabilitation vegetation type where available. Where such a resource is limited due to presence within cleared disturbance areas an alternative topsoil resource will be selected based on potential species composition, or rehabilitation will be conducted without topsoil and appropriate adjustments made to seed mixes to enhance species richness and plant establishment levels.

12.3.3 Revegetation

With regard to revegetation, the general approach will be to target for re-establishment of the:

- dominant or keystone plant taxa in vegetation supergroup(s) associated with the landform
- taxa that are of special significance.

Table 12-8 outlines which supergroups will be targeted for each area. See **Section 5** for a description of each supergroup.

TABLE 12-8: PROPOSED VEGETATION SUPERGROUPS FOR REHABILITATION

Domain	Current Vegetation Supergroup	Proposed Landform	Recommended Supergroup Targeted for Rehabilitation
Open pits	PSRN PNC	Backfilled southern node at Bungalbin East and potentially the pit floors in the northern node at Bungalbin East and at J5.	PNC with potential for PSRN elements in backfilled areas.
Waste rock landforms	PNC PCS	Slopes and crests.	PNC on slopes and crests with potential for PSRN on crests.
Supporting infrastructure	PCS	Similar landform to pre-disturbance.	PCS
Haul roads and linear infrastructure	PCS	Similar landform to pre-disturbance.	PCS

The intention is to use provenance seed, either through establishment of plants germinating from the topsoil seed bank or from seed collected from plants and the land surface prior to disturbance. The latter would be cleaned and stored for subsequent use.

The successful implementation of this phase of closure and rehabilitation warrants investigations into how successful outcomes can be optimised. These investigations might include:

- assessment of the viability of seed in topsoil and determination of its likely longevity
- determination of optimal soil profile construction and soil treatment options, and their effect on plant establishment and survival
- viability of collected seed and impact of storage conditions and time on viability
- calculation of suitable seeding rates to optimise seed stores.

Yates et al (2011) discuss the difficulties of re-establishing the BIF endemics that occupy the cracks in massive BIF. In particular they looked at four different *Tetratheca* taxa and their ecological preferences. Three taxa grew exclusively in fissures within massive rock substrates and the fourth (*Tetratheca aphylla*) grew on shallow skeletal soils overlying massive ironstone. While this demonstrates that the ecological preferences for *T. aphylla* are broader than other *Tetratheca* taxa, it also highlights that there are likely to be taxa at the HAR that have very specific requirements in relation to their referred habitat e.g. *Leucopogon spectabilis* is another taxon than appears to occur exclusively in fissures. Ecological preferences for individual taxa of conservation significance will need to be considered in detail when planning and implementing rehabilitation works.

The literature review (**Appendix 12-C**) and the review by Woodman Environmental (**Appendix 5-G**) highlighted MRL's limited experience in rehabilitation and restoration activities associated with conservation-significant flora and communities. Nevertheless, Woodman Environmental concluded that "research and investigations within the broader BIF iron ore industry indicates the potential for successful propagation, establishment and survival of BIF specialist flora on appropriate translocation sites, with research results to date providing a firm basis for MRL to build upon when developing management strategies for their operations at the Helena-Aurora Range." MRL also draws attention to its partnership in an Australian Research Council (ARC) project aimed at contributing to training and research into mine site restoration techniques. The ARC Industrial Transformation Training Centre (ITTC) for Mining Restoration commenced in 2015.

12.4 Residual impacts

The residual impacts associated with rehabilitation and decommissioning will depend on how well the mine rehabilitation program can be planned and implemented.

The literature review (**Appendix 12-C**), summarised in **Section 12.2.5**, suggests that, while the industry is often slow to complete rehabilitation works to a standard that enables relinquishment of tenements, performance is significantly better where a higher standard of rehabilitation is required.

MRL acknowledges the company's limited experience in this area but points to other operations where successful rehabilitation outcomes are being achieved at mining projects associated with banded iron formations, and commits to completing rehabilitation to a similar standard. Where particular attention is paid to topsoil and subsoil management, and special measures adopted for return or translocation of target taxa, successful outcomes appear within reach.

12.5 Predicted outcome

MRL considers rehabilitation and closure to be a critical aspect of the J5 and Bungalbin East Proposal and acknowledges that successful implementation is necessary to maintain the natural values of the HAR and the MMHARCP. In compiling this impact assessment, MRL has concluded that successful implementation is challenging but achievable and that the EPA's objective for rehabilitation and decommissioning can be met.

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13. OFFSETS

13.1 EPA objective, policies and guidance

The EPA objective for offsets as an integrating factor is:

- to counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.

The policy and guidance documents referenced as part of the impact assessment are described in **Table 13-1**.

TABLE 13-1: LEGISLATION, POLICIES AND GUIDANCE CONSIDERED DURING EIA

Legislation, Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
EPA (2014). Environmental Protection Bulletin No. 1: Environmental offsets. Perth, Western Australia.	Clarifies how the EPA will consider offsets through the EIA process, in the context of the WA Environmental Offset Policy and WA Environmental Offset Guidelines (see below).	Referenced in **Section 13.3** of the PER in regard to timing of determination of offset package.
Non-EPA Policy and Guidelines		
Government of Western Australia (2011). WA Environmental Offsets Policy. Perth, Western Australia.	Provides a framework to underpin environmental offset assessment and decision-making in Western Australia. It seeks to ensure that environmental offsets are applied in specified circumstances in a transparent manner to engender certainty and predictability, while acknowledging that there are some environmental values that are not readily replaceable.	Principles governing offsets summarised in **Section 13.1** of PER.
Government of Western Australia (2014). WA Environmental Offsets Guidelines. Perth, Western Australia.	Expands on the WA Environmental Offsets Policy (above) by clarifying the determination, application and types of offsets in Western Australia.	Guideline accompanying offsets template (**Appendix 13-A**).
WA Environmental Offsets template (230914)	Accompanies the WA Environmental Offsets Guidelines.	**Appendix 13-A**.
Commonwealth Policy and Guidelines		
Department of Sustainability, Environment, Water, Population and Communities (2012). *Environment Protection and Biodiversity*	Outlines the Australian Government's approach to the use of environmental offsets and provides transparency around how	Referenced in **Section 13.2** of PER but State guidelines used as primary guidance at this

Legislation, Policy and Guidelines	Key Aspects	Application
Conservation Act 1999: Environmental Offsets Policy. Canberra, ACT.	the suitability of offsets is determined.	stage. See also **Section 14.2.4**.

In summary, the requirement for and application of offsets should be consistent with Western Australia's Offsets Policy (Government of Western Australia, 2011). This policy outlines the principles under which offsets apply. These principles are:

- Offsets are only considered after avoidance and mitigation options have been pursued.
- Offsets are not appropriate for all projects.
- Offsets will be cost-effective as well as relevant and proportionate to the significance if the environmental value being offset.
- Offsets will be based on sound environmental information and knowledge.
- Offsets will be applied within a framework of adaptive management.
- Offsets will focus on longer term strategic outcomes.

Offsets may also apply under Commonwealth legislation (Department of Sustainability, Environment, Water, Populations and Communities, 2012). However, offsets under the EPBC Act will not be specifically covered here as the relevant factors are common with those considered under Western Australian legislation. The Proposal is being assessed under a bilateral agreement (see **Section 1.5.1**) and "formal consultation mechanisms exist for interaction between the agencies to align any offsets requirement" (Government of Western Australia, 2014; Environmental Protection Authority, 2014c).

13.2 Significant residual impacts

Section 5 to **Section 11** of the PER consider the environmental impacts associated with a range of factors. Of these, MRL considers that the Proposal will have a significant residual impact on only one factor - flora and vegetation. Residual impacts are those that remain after mitigation measures - avoidance, minimisation and rehabilitation – have been applied. If these impacts are still considered significant, offsets may be appropriate to further reduce the net impact.

In the case of flora and vegetation, impacts are occurring to species and communities protected under the WC Act and the EPBC Act.

The significant residual impacts identified in relation to flora and vegetation are outlined in **Table 13-2**.

13.3 Proposed offsets

In considering the significant residual impacts listed in **Table 13-2**, a program of proposed offsets has been developed. The proposed offsets are listed in **Appendix 13-A** (using the WA offsets template) and in **Table 13-3**.

TABLE 13-2: SIGNIFICANT RESIDUAL IMPACTS – FLORA AND VEGETATION

Aspect of Flora and Vegetation	Significant Residual Impact	Offsets proposed
Helena and Aurora Range vegetation complexes (banded ironstone formation) Priority Ecological Community (PEC)	Removal of 349.2 ha (6.3 %) of the PEC. Given there is little other existing disturbance, over 90 % of the PEC would remain if this Proposal was implemented. Extent to which rehabilitation can restore PEC values is not clear but mining will significantly change landforms at the local scale.	MRL holds a number of exploration tenements in the region, including E77/842-I which covers the majority of the HAR (see **Figure 1-3**). MRL is obliged to rehabilitate any existing disturbance its tenements except where the disturbance was pre-existing to the grant. In consultation with DMP and DPaW, MRL proposes to rehabilitate all disturbance on MRL group exploration tenure within the MMHARCP, including pre-grant disturbance. Subject to suitable conservation tenure arrangements to afford protection being in place, MRL intends to relinquish all MRL group exploration tenure in the MMHARCP in a manner satisfactory to DMP and DPaW.
Individual vegetation units contained within the PSRN supergroup and which host taxa of conservation significance.	Particular vegetation units affected are PSRN6, PSRN7 and PSRN23. PSRN7, a eucalypt woodland occurring on the slopes below the ridgeline, has a current extent of less than 50 ha of which just over 30 % would be removed under the Proposal.	
Tetratheca aphylla subsp. *aphylla* (Threatened)	Loss of over 25,000 individuals (29.4 %) of the local population. This taxon is not known outside of the HAR. Some plants within the disturbance area of the Bungalbin East pit exhibit some degree of genetic differentiation from plants outside of this area.	Preparation and implementation of an interim recovery plan.
Lepidosperma bungalbin (P1).	Loss of over 18,000 individuals (39.7 %) of the species. This taxon is not known outside of the HAR but is locally abundant on steep BIF slopes. Potential for reintroduction to disturbed areas through rehabilitation.	Preparation and implementation of a research plan and an interim recovery plan.

TABLE 13-3: SUMMARY OF PROPOSED OFFSETS

Offset aspect	Details
Offset 1: Off-site rehabilitation in MMHARCP	
Objective	Rehabilitate all historical disturbance on MRL group exploration tenure in the MMHARCP, including filling in costeans, ripping of exploration tracks, drill hole rehabilitation, removal and disposal of mineral sample bags and other debris, and weed management. Subject to suitable conservation tenure arrangements to afford protection being in place, MRL intends to relinquish all MRL group exploration tenure in the MMHARCP in a manner satisfactory to DMP and DPaW.
Completion criteria	Preparation of rehabilitation plan; implementation of rehabilitation plan; tenement relinquishment.
Plans and policies	No existing management plan for HAR.
Milestones	Acceptance of rehabilitation plan by DMP and DPaW; completion of works to the satisfaction of DMP and DPaW; tenement relinquishment.
Governance	Public availability of plan through www.offsetsregister.wa.gov.au.
Financial arrangements	Costs to be met by MRL (over a particular time period to be determined).
Risk management	All rehabilitation works to require DMP and DPaW approval when complete.
Monitoring	Inspection by DMP and DPaW.
Reporting	Annual progress and final close out reports.
Offset 2: *Tetratheca aphylla subsp. aphylla* - Interim Recovery Plan	
Objective	Preparation and implementation of an interim recovery plan for *Tetratheca aphylla* subsp. *aphylla.*
Completion criteria	Preparation of interim recovery plan; implementation of various aspects of the plan (to be determined).
Plans and policies	No existing plan for this taxon.
Milestones	Approval of interim recovery plan by DPaW; progress reports.
Governance	Public availability of plan through DPaW and www.offsetsregister.wa.gov.au.
Financial arrangements	Costs to be met by MRL (over a particular time period to be determined).
Risk management	Approval of plan by DPaW.
Monitoring	Meetings to assess progress, review monitoring data and initiate further action; field inspections to confirm results.
Reporting	Update of interim recovery plan every four years.
Offset 3: *Lepidosperma bungalbin* - Research Plan and Interim Recovery Plan	
Objective	Preparation and implementation of a research plan for *Lepidosperma bungalbin*; preparation and implementation of an interim recovery plan for

Offset aspect	Details
	Lepidosperma Bungalbin.
Completion criteria	Preparation of research plan; implementation of research plan; preparation of interim recovery plan; implementation of various aspects of the plan (to be determined).
Plans and policies	No existing plan for this taxon.
Milestones	Approval of research plan by DPaW; interim recovery plan by DPaW; progress reports.
Governance	Public availability of plans through DPaW and www.offsetsregister.wa.gov.au.
Financial arrangements	Costs to be met by MRL (over a particular time period to be determined).
Risk management	Approval of plans by DPaW.
Monitoring	Meetings to assess progress, review monitoring data and initiate further action; field inspections to confirm results.
Reporting	Close out report for research plan; update of interim recovery plan every four years.

A summary of the proposed offsets is provided here for ease of reference:

- Off-site rehabilitation (rehabilitation of historical mineral exploration disturbance within the MMHARCP).
- *Tetratheca aphylla* subsp. *aphylla* - Interim Recovery Plan. It is anticipated the Plan would include reproduction of plants through seed germination and from cuttings with a view to translocation of plants to suitable sites in the HAR or elsewhere within the MMHARCP. Plants occurring within the proposed Bungalbin East pit would be a particular focus prior to any ground disturbance. Some preliminary investigations into seed banks and seed collection, and establishment of plants from cuttings, has shown the species can be readily propagated (Botanic Gardens and Parks Authority, 2010).
- *Lepidosperma bungalbin* - Research Plan and Interim Recovery Plan (including potential translocation to other suitable sites with the HAR).

MRL has commenced making an ongoing financial contribution to the consortium of mining companies and academic institutions implementing a $7 million Australian Research Council grant. The grant involves the establishment and implementation of an integrated research training program for mine rehabilitation that is focussed on improved mining rehabilitation outcomes and better conservation management of significant biodiversity assets where effects from mining cannot be avoided. MRL's view is that this contribution potentially qualifies as an offset for this Proposal.

MRL acknowledges that "the requirement for any offsets is not determined by the EPA until the final stages of the assessment process" (EPA 2014). Consequently, MRL anticipates that further discussions will flow from the PER and/or in subsequent stages of the assessment process. It is expected that further details will become available on the offsets that will form a component of this Proposal. These details will include objectives and completion criteria, timelines and milestones, governance and financial arrangements, risk management and reporting.

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14. SUMMARY OF MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

14.1 Introduction

Matters of national environmental significance relate to matters receiving protection under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the biodiversity provisions of this Act, two plant taxa are protected. These taxa are discussed in detail in **Section 5** and in summary form in this section.

Schedule 4 of the *Environment Protection and Biodiversity Conservation Regulations 2000* requires particular matters to be addressed within an environmental impact statement. How these matters are addressed in this PER is outlined in **Appendix 14-A**.

14.2 Listed threatened flora species

Two threatened flora species listed under the EPBC Act have been recorded within the disturbance area and elsewhere on the HAR, namely Bungalbin Tetratheca (*Tetratheca aphylla* subsp. *aphylla*) and Ironstone Beard-heath (*Leucopogon spectabilis*). Both species are endemic to the HAR.

L. spectabilis is mainly restricted to the central portion of the HAR with only several plants occurring within the disturbance area. *T. aphylla* subsp. *aphylla* is more widely distributed across the HAR with a significant number of plants occurring within the disturbance area.

14.2.1 Potential impacts

The potential impacts of the Proposal on listed threatened flora species include direct impacts arising from clearing as well as indirect impacts such as:

- foliar dust deposition and loss of condition;
- introduction and/or spread of weeds; and
- fragmentation and adverse changes to microhabitats.

The Proposal will remove less than 1% of the total number of plants of *L. spectabilis* and 29.4% of the total number of plants of *T. aphylla* subsp. *aphylla* (**Table 14-1**). Note that the potential impact has been assessed including plants in a 20 m buffer around the proposed pit, waste rock landforms and supporting infrastructure to account for indirect impacts.

The potential impact on L. spectabilis and T. aphylla subsp. aphylla from foliar dust deposition is manageable, although measures to minimise and monitor dust emissions from mining operations are warranted to ensure mining operations do not have an adverse impact in this regard.

TABLE 14-1: POTENTIAL IMPACT ON LISTED THREATENED FLORA

Taxon	Total no. of plants recorded	No. of plants within mine disturbance area	No. of plants within 20 m buffer zone	Proposed impact (%) – direct and indirect
Leucopogon spectabilis (Ironstone Beard-heath)	14,434	130	0	0.9
Tetratheca aphylla subsp. *aphylla* (Bungalbin Tetratheca)	87,921	25,069	818	29.4

The potential impact on these two listed threatened flora species from the introduction and/or spread of weeds is also manageable. The primary risk lies with the inadvertent introduction of weed seed to the site. This risk can be readily minimised through the application of routine weed monitoring and hygiene/treatment procedures.

The potential impact on these listed threatened flora species from fragmentation and adverse changes to microhabitats is less well understood but is not likely to be significant, particularly with regard to *L. spectabilis* as the largest population of this species occurs more than one kilometre from the Bungalbin East pit.

14.2.2 Feasible alternatives and possible mitigation measures

Direct loss of plants as result of land clearing for mine pit development will have the greatest potential impact on listed threatened flora species under the EPBC Act.

Consideration of alternatives to direct impacts is constrained by the fact that the mine pits cannot be avoided or substantially reduced in size as they contain the mineral resource that is central to economic viability of the Proposal.

In terms of possible mitigation measures, MRL has defined a conservative disturbance area to allow flexibility for mining, but for the purpose of assessing potential impacts has assumed all plants will be lost within this area. In practice, it will be possible to avoid some listed threatened flora species that occur within these buffer areas. This can be achieved through careful detailed mine design and controlled by existing MRL procedures for land clearing (MRL-EN-PRO-0004) and site disturbance (MRL-EN-PRO-0005).

MRL has also considered management of indirect impacts to minimise potential adverse effects on listed threatened flora species. For impact assessment purposes, MRL has assumed all plants included in a 20 m buffer around the areas of direct impact will be lost (**Table 14-1**). MRL's objective will be to retain all plants within the buffer area. This will be undertaken through implementation of existing MRL plans and procedures, complemented by monitoring and some additional site-specific plans and procedures.

A monitoring program is required to identify and respond to adverse impacts arising from mine operations. This program will be capable of distinguishing between localised impacts that are potentially attributable to mining operations versus general environmental conditions, such as an extended period of low rainfall. This monitoring program is outlined as part of the Conservation Significant Species and Communities Management Plan (**Appendix 5-H**).

14.2.3 Residual impacts

The residual impacts of the Proposal on threatened flora protected under the EPBC Act, once all efforts to avoid, minimise and rehabilitate have been implemented, comprise the removal of

- approximately 26,000 individuals (29.4 %) of the threatened taxon *Tetratheca aphylla* subsp. *aphylla* – this taxon is not known outside of the HAR and some plants within the disturbance area at Bungalbin East exhibit a degree of genetic differentiation from plants elsewhere on the range
- small numbers of individuals (~1 % or less) of the threatened taxon *Leucopogon spectabilis* - neither species is known outside of the HAR.

These residual impacts on these taxa are not expected to warrant reconsideration of their IUCN threat ratings (**Appendix 5-D**); however the residual impact is significant and MRL proposed to offset this impact.

14.2.4 Proposed offsets

Targeted offsets are proposed to counter balance the residual significant impact on *Tetratheca aphylla* subsp. *aphylla*. The proposed offset comprises contribution towards preparation and implementation of an Interim Recovery Plan for *Tetratheca aphylla* subsp. *aphylla*. It is anticipated the Plan would include reproduction of plants through seed germination and from cuttings with a view to translocation of plants to suitable sites in the HAR or elsewhere within the MMHARCP. Plants occurring within the proposed Bungalbin East pit would be a particular focus prior to any ground disturbance. Some preliminary investigations into seed banks and seed collection, and establishment of plants from cuttings, has shown the species can be readily propagated (Botanic Gardens and Parks Authority, 2010).

14.3 Listed threatened fauna species

One threatened fauna species listed under the EPBC Act was recorded by ecologia Environment (**Appendix 8-A**) within the sand plains in the south west extremity of the study area, namely Malleefowl (*Leipoa ocellata*). This record is approximately 11 km from the disturbance area.

The Malleefowl is a large, ground-dwelling bird that inhabits thickets of mallee, mulga or other dense litter-forming shrublands as well as dry forest dominated by other eucalypt and acacia species (Johnstone & Storr, 1998; Benshemesh, 2005).

This species was once common and widespread across semi-arid southern Australia but has declined severely both in terms of abundance (20% decrease) and area of occupancy (50% decrease) (Garnett & Crowley, 2000; Benshemesh, 2005).

This species was recorded by ecologia Environment (**Appendix 8-A**) within the sandy plain with shrubland habitat type via secondary evidence in the form of recently used mounds (1-5 years old). No active mounds were recorded within the study area, despite extensive searches undertaken as part of both flora and fauna surveys conducted over the period 2012-2014. In addition to the mounds, fresh tracks of the species were detected during the field survey and one individual was sighted opportunistically approximately 8 km east from the study area eastern boundary.

There are numerous records of this species' occurrence within 100 km of the study area, particularly further west towards the Mt Jackson Range.

14.3.1 Potential impacts

The potential impacts of the Proposal on Malleefowl are limited to injury and/or death of Malleefowl individuals arising from vehicle operations associated with mining activities. This impact will not be significant based on the absence of any significant populations in the area surrounding the Proposal.

Potential impacts in the form of displacement and/or loss of Malleefowl arising from degradation, fragmentation or loss of suitable habitat are not expected, on the basis that the majority of the disturbance area does not contain the sandy shrubland habitat type that this species prefers, nor any evidence of previous or current use by Malleefowl.

14.3.2 Feasible alternatives and possible mitigation measures

Feasible alternatives to the Proposal have not been considered with regard to potential impacts on Malleefowl; however mitigation measures will be implemented to ensure that injury and/or death of Malleefowl from vehicle strike is reduced as low as possible.

In practice, it will be possible to avoid some listed threatened flora species that occur within these buffer areas. This can be achieved through careful detailed mine design and controlled by existing MRL procedures for land clearing (MRL-EN-PRO-0004) and site disturbance (MRL-EN-PRO-0005).

MRL has also considered management of indirect impacts to minimise potential adverse effects on listed threatened fauna species. These include existing MRL plans and procedures complemented by monitoring and some additional site-specific plans and procedures.

Potential impacts to Malleefowl can be effectively managed through implementation of MRL's Environmental Management System for the Proposal, which includes plans and procedures relevant the management of fauna (**Table 14-2**). The EMS for the Proposal will be certified and maintained to the international standard AS/NZS ISO 14001:2004.

TABLE 14-2: MANAGEMENT OF MALLEEFOWL – MRL PLANS AND PROCEDURES

Doc. No	Title	Description
MRL-EN-POL-0001	Environment and Community	Company policy in relation to the environment and communities.
MRL-EN-PLN-0001	Environmental Management Plan	Outlines the systematic approach to environmental management.
MRL-EN-PRO-0001	Fauna Management	Describes procedures for management of native fauna
MRL-OHM-PRO-0007	Incident Reporting	Outlines MRL's requirements in regard to incident classification and required timeframes for the reporting of incidents by impact type and actual and potential consequence level.
MRL-TS-WIN-0007-02	Malleefowl Conservation	Outlines work instructions for protecting populations of Malleefowl, minimising impacts on Malleefowl habitat and enhancing understanding of the conservation status and management of Malleefowl.

The management plans and procedures outlined above are expected to assist the management of threatened fauna such as Malleefowl, and to this extent the Proposal is consistent with the National Recovery Plan for this species (refer Benshemesh (2007)).

14.3.3 Residual impact

The residual impact of the Proposal on Malleefowl, once all efforts to minimise avoid, minimise and rehabilitate the proposed extent of disturbance, is predicted to be limited to occasional injury and/or death of individual animals from vehicle strike. This impact is not significant.

15. ENVIRONMENTAL PROTECTION

The object of the EP Act is to protect the environment of the Western Australia having regard to the principles described in **Table 15-1**. An evaluation of the Proposal in the context of these principles is also provided in **Table 15-1**.

TABLE 15-1: PRINCIPLES OF THE EP ACT

Description of principle	Evaluation
1. Precautionary principle	
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. In the application of the precautionary principle, decisions should be guided by: a) careful evaluation to avoid, where practicable serious or irreversible damage to the environment; and b) an assessment of the risk-weighted consequences of various options.	The environment within which the Proposal is situated is well understood as a result of investigations by MRL and others over many years. Scoping of relevant preliminary key environmental factors was undertaken by the EPA following referral of the Proposal and, in particular, as part of the ESD prepared by the EPA. MRL has undertaken the necessary environmental studies and has prepared the PER in accordance with the requirements of the ESD. MRL has carefully evaluated mine and infrastructure layout to avoid, where practicable, serious or irreversible damage to the environment. It has also assessed the alternatives to the Proposal (refer to **Section 2** for details). A precautionary approach has been adopted by MRL to the identification of management measures and controls that will be applied to mitigate potential environmental degradation associated with the Proposal. The level of information in this PER document is therefore sufficient to assess the significance of the impacts of the Proposal on the environment. Accordingly, the Proposal is consistent with this principle of the EP Act.
2. Intergenerational equity	
The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	MRL's environment and community policy recognises that its operations have the potential to impact on environmental and community values. The potential impacts of the Proposal on the key conservation and recreation values associated with the Helena-Aurora Range are assessed in the PER document with respect to the preliminary key environmental factors 'flora and vegetation' and

Description of principle	Evaluation
	'amenity'. MRL's application of the mitigation hierarchy can effectively reduce the predicted residual impacts to the extent that environmental health, diversity and productivity will not be compromised between this generation and the next. In other words, the conservation and recreation values associated with the HAR will remain for the benefit of future generations, even if the Proposal is implemented. The Proposal is therefore consistent with this principle of the EP Act.
3. Conservation of biological diversity and ecological integrity	
Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Biological diversity and ecological integrity are fundamental considerations for mining proposals in the BIF ranges. MRL has undertaken numerous flora, vegetation and fauna surveys over multiple seasons across its tenements. These investigations provide site-specific information on threatened and priority flora and ecological communities, the significance of which is adequately understood based on the broader regional context. MRL has quantified the direct and indirect loss of vegetation and habitat as a result of the Proposal, as well as the number of individual plants with regard to conservation significant species. MRL has minimised the impact by locating infrastructure to avoid threatened and priority species and ecological communities wherever possible. Partial backfilling of the southern pit at Bungalbin East will also reduce the impact. The Proposal includes progressive rehabilitation of disturbed areas, as set out in the Rehabilitation and Mine Closure Plan, as well as offset proposals where there are significant residual impacts on threatened flora. The conservation of biological diversity and ecological integrity has therefore been a fundamental consideration throughout the development of the Proposal, which is consistent with this principle of the EP Act.

Description of principle	Evaluation
4. Improved valuation, pricing and incentive mechanisms	
a) Environmental factors should be included in the valuation of assets and services b) The polluter pays principle — those who generate pollution and waste should bear the cost of containment, avoidance or abatement c) 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; and d) 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 response to environmental problems	MRL takes responsibility for all costs and the potential for pollution and waste associated with the Proposal. These principles are also addressed by government processes broader than Part IV EP Act assessment and approval. The Proposal is designed to minimise the impact of pollution from aspects of the Proposal such as waste disposal as well as storage and handling of dangerous goods. Waste will be minimised through a combination of on-site treatment as well as off-site treatment of more hazardous waste streams. Refer also Principle 5.
5. Waste minimisation	
All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Waste generated by the Proposal will be managed in accordance with applicable regulatory standards and internal operating procedures. The Proposal also includes measures to minimise waste generation by encouraging reuse, recycling and reduction of products, where possible. As part of the EMS development for the Proposal, all reasonable and practicable measures to minimise the generation of waste and its discharge into the environment will be taken. Therefore, the Proposal is consistent with this principle of the EP Act.

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16. CONCLUSION

This Public Environmental Review (PER) provides MRL's assessment of the potential environmental impact of the J5 and Bungalbin East Iron Ore Proposal in accordance with the requirements of the Western Australian Environmental Protection Authority (EPA) and the Australian Government Department of the Environment and Energy (DEE).

The PER assesses the potential impacts of the Proposal on each of the preliminary key environmental factors identified in the Environmental Scoping Document (ESD), including relevant matters of national environmental significance protected under Commonwealth law, once management has been applied to avoid, minimise and rehabilitate the impacts. It also identifies the significance of the residual impacts of the Proposal in terms of:

- the EPA's significance framework, as outlined in the EPA's Environmental Assessment Guideline 9, including evaluation of the extent to which the Proposal is consistent with the EP Act
- the Australian Government's significant impact criteria as outlined in the significant impact guidelines 1.1.

Each requirement of the ESD has been addressed. A checklist is provided to cross reference each ESD requirement with the PER content (**Appendix 1-C**).

As part of the application of the mitigation hierarchy, MRL has carefully considered mine site design and layout to avoid impacts where possible. This process of optimisation has focussed on the location and design of waste rock landforms, supporting infrastructure and haul roads as these aspects of the Proposal are more readily located and/or designed to avoid impacts. The ore bodies, and the open pits required to be excavated to recover the ore, are fixed and cannot be located elsewhere, although partial backfilling of the southern pit at Bungalbin East will create a landform capable of supporting native vegetation.

In addition to avoiding impacts where possible, MRL will implement a range of management plans and procedures to minimise and rehabilitate impacts. Some of these plans and procedures have already been developed and currently apply across all of MRL's operations. Other plans and procedures have been developed specifically for the Proposal. Together, these plans and procedures will comprise the Environmental Management System (EMS) for the Proposal. Should the Proposal receive approval under the EP and EPBC Acts, MRL proposes to seek certification of its EMS, as it applies to the Proposal, to the ISO 14001 international standard.

When taking into account the application of the mitigation hierarchy in respect of the Proposal, MRL considers that the potential residual impact of the Proposal on the following preliminary key environmental factors will not be significant:

- Landforms
- Subterranean fauna
- Terrestrial fauna
- Hydrological processes and inland waters environmental quality
- Amenity
- Heritage

For the preliminary key environmental factor 'flora and vegetation', a significant residual impact is predicted to occur despite efforts to avoid, minimise and rehabilitate these impacts. MRL considers the significant residual impacts to be:

- direct and indirect impact to 6.9% of the Helena and Aurora Range Vegetation Complexes (Banded Ironstone Formation) Priority Ecological Community.
- direct and indirect impact to 29.4% of the threatened *Tetratheca aphylla* subsp. *Aphylla*.
- direct and indirect impact to 39.7 % of *Lepidosperma Bungalbin* - the species is currently listed as Priority one, however the data from this PER may warrant the species to be upgraded to vulnerable.
- removal of 2.1% of the PSRN Vegetation Supergroup - two individual PSRN vegetation units will be impacted by 37.2 % and 36.3 % respectively.

MRL proposes to offset this significant residual impact so as to reduce the overall impacts to an acceptable level.

The PER evaluates the environmental acceptability of the Proposal with respect to: (a) the principles of the EP Act; (b) relevant environmental policies and guidance published by the EPA and other government agencies, including the Australian Government; and (c) the EPA objectives for the preliminary key environmental factors identified in the ESD.

The Proposal is consistent with the principles of the EP Act and MRL has endeavoured to meet the intent of relevant environmental policies and guidance throughout the development of the Proposal and its assessment as part of the preparation of the PER. Despite the predicted significant residual impact on flora and vegetation, the Proposal is capable of meeting the EPA objective for this preliminary key environmental factor by maintaining representation, diversity, viability and ecological function at the species, population and community level

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18. GLOSSARY

ABA	Acid Base Account
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Inquiry System
AMP	Amenity Management Plan
ANC	Acid neutralising capacity
ARD	Acid rock drainage
BIF	Banded iron formation
CSM	Conceptual site model
CSSCMP	Conservation-Significant Species and Communities Management Plan
DAA	Department of Aboriginal Affairs
dB	Decibel
DER	Department of Environmental Regulation
DMA	Decision-making authority
DPaW	Department of Parks and Wildlife
EIA	Environmental Impact Assessment
ENSO	El Niño-Southern Oscillation
EP Act	*Environmental Protection Act 1986* (Western Australia)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ESD	Environmental Scoping Document
HAR	Helena-Aurora Range
HAR PEC	Helena and Aurora Range vegetation complexes (banded ironstone formation) Priority Ecological Community (as defined by DPaW)
HAR PEC analogue	An analogue of the HAR PEC defined by ecologia
IUCN	International Union for Conservation of Nature
LAU	Local Assessment Unit
LIA	Landform Impact Assessment
MD	Metalliferous drainage
MMHARCP	Mt Manning - Helena-Aurora Range Conservation Park
MRL	Mineral Resources Ltd
Mygalomorph spiders	An order of large spiders including trap-door spiders
NAF	Not acid-forming
OHP	Other Heritage Place
PAF	Potentially acid-forming

PAL	Potentially Affected Landform
PDCA	Plan-Do-Check-Act
PEC	Priority Ecological Community
PM_{10}	Particulate matter < 10 µm/m^3
$PM_{2.5}$	Particulate matter < 2.5 µm/m^3
PMF	Probable Maximum Flood
RMCP	Rehabilitation and Mine Closure Plan
SDM	Species distribution model
SRE	Short-range endemic invertebrate
Stygofauna	Fauna that live in groundwater systems or aquifers.
TPI	Topographic Position Index
Troglofauna	Fauna that live underground in caves and smaller air-filled voids beneath the ground.
TSP	Total suspended particulates
UCL	Unallocated Crown land (previously known as Vacant Crown land)
VIA	Visual Impact Assessment
WC Act	*Wildlife Conservation Act 1950* (Western Australia)
Weed hygiene	Management practices designed to prevent the introduction or spread of weed seed.
Wind roses	Wind roses summarise the occurrence of winds at a location, showing their strength, direction and frequency. Each branch of the rose represents wind coming from that direction.
WRL	Waste rock landform

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