AUDALIA RESOURCES LIMITED

MEDCALF PROJECT
DRAFT ENVIRONMENTAL REVIEW DOCUMENT

2 March 2021
Assessment Number: 2156
Document ID: AUD-MED-ERD-01

Prepared for Audalia Resources Limited
by Preston Consulting Pty Ltd

CONTACT DETAILS

Proponent:

AUDALIA RESOURCES LIMITED

Contact Person: Geoffrey Han – Project Director
Email: geoffrey.han@audalia.com.au
Phone: +61 8 9321 0715
Address: Level 1, Office F, 1139 Hay Street, West Perth, WA, 6005
Postal Address: PO Box 354, West Perth, WA, 6872

Document developed by:

PRESTON CONSULTING PTY LTD

Contact Person: Gavin Edwards - Director
Email: gedwards@prestonconsulting.com.au
Website: www.prestonconsulting.com.au
Phone: +61 8 9221 0011
Fax: +61 8 9221 4783
Street Address: Level 3, 201 Adelaide Terrace, East Perth, WA, 6004
Postal Address: PO Box 3093, East Perth, WA, 6892

Disclaimer:

DOCUMENT CONTROL

Document Title	Medcalf Project – Environmental Review Document		
Document Number	AUD-MED-ERD-01		
Revision Number	**0**		**2/03/2021**
Status	Final		
Author 1	Marilyn Quintero/ Blake Marxsen Preston Consulting Pty Ltd	Signature	2/03/2021
Checked	Gavin Edwards Preston Consulting Pty Ltd	Signature	2/03/2021
Approved	Geoffrey Han Audalia Resources Limited	Signature	2/03/2021

INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this proposal. Audalia Resources Limited (Audalia) seeks to develop a vanadium, titanium and iron mining operation, approximately 100 km southwest of Norseman, Western Australia (WA).

The Proposal includes the development of open mine pits, beneficiation plant, tailings storage facility, evaporation ponds, mine closure materials area, topsoil stockpile, private haul road, road train transfer area and associated infrastructure such as laydown areas, borrow and gravel pits, groundwater bores, workshops and accommodation camp.

This Environmental Review Document (ERD) has been prepared in accordance with the EPA's Procedures Manual (Part IV Divisions 1 and 2). The ERD is the report by the proponent on their environmental review which describes this proposal and its likely effects on the environment. This ERD is available for a public review period of eight weeks from 8 March 2021, closing on 2 May 2021.

Information on the proposal from the public may assist the EPA to prepare an assessment report in which it will make recommendations on the proposal to the Minister for Environment.

Why write a submission?

The EPA seeks information that will inform the EPA's consideration of the likely effect of the proposal, if implemented, on the environment. This may include relevant new information that is not in the ERD, such as alternative courses of action or approaches. 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*.

Why not join a group?

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. 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 information in the ERD. When making comments on specific elements in the ERD, ensure that you:

- Clearly state your point of view and give reasons for your conclusions.
- Reference the source of your information, where applicable.
- Suggest alternatives to improve the outcomes on the environment.

What to include in your submission

Include the following in your submission to make it easier for the EPA to consider your submission:

- Your contact details – name and address;
- Date of your submission;
- Whether you want your contact details to be confidential;
- Summary of your submission, if your submission is long;
- List points so that issues raised are clear, preferably by environmental factor;
- Refer each point to the page, section and if possible, paragraph of the ERD; and
- Attach any reference material, if applicable. Make sure your information is accurate.

The closing date for public submissions is: 2 May 2021

The EPA prefers submissions to be made electronically via the EPA's Consultation Hub at https://consultation.epa.wa.gov.au.

Alternatively submissions can be:

- Posted to: Chairman, Environmental Protection Authority, Locked Bag 10, Joondalup DC, Joondalup WA 6919, or
- Delivered to: the Environmental Protection Authority, 8 Davidson Terrace, Joondalup, WA 6027.

If you have any questions on how to make a submission, please contact the EPA Services at the Department of Water and Environmental Regulation on 6364 7000.

SCOPING CHECKLIST

Task No.	Required Work	Section and Page No.
Flora and Vegetation		
1	A desktop review of available technical reports, relevant databases and spatial data to identify the known potential flora and vegetation that may be present.	5.3 Appendix 3.9
2	A detailed two-season flora and vegetation survey covering the Medcalf project mine study area and the haul road study area in accordance with current EPA technical guidance. Survey is to include: • Targeted searches for populations of plants of significance to identify the local and regional extent of affected taxa, including *M. aquilonaris*, *E. rhomboidea* and *S. bremerense*; • Opportunistic searches for populations of exotic plant species (weeds), particularly declared plants; • Define and map the vegetation communities of the Study Area at NVIS Level 5 Association with statistical validation of vegetation communities described and in accordance with the standard requirements and protocols applied for BIF / Greenstone surveys; • Extend vegetation mapping beyond the disturbance footprint defined to include a minimum 1 km wide alignment for linear infrastructure to give local context of vegetation associations intercepted; • Develop an inventory of all flora of the Study Area, including known significant flora (i.e. priority/threatened flora, range extensions, novel species, subspecies or hybrids); • A review of the local and regional significance of the flora and vegetation types recorded where significant vegetation are defined to include those associations with limited distribution within the Study Area which may be associated with specific landscape and or soil profile stratigraphy, or GDEs; • Record of the condition of vegetation; and • Report should include maps depicting survey methods (quadrats, transects, etc.) and results (significant flora, vegetation).	5.3 Appendix 3.9
3	Undertake a groundwater abstraction study to determine required drawdown rates and depths. A survey will be conducted for GDE boundaries and species composition within the drawdown zone if groundwater drawdown rates or depths are expected to result in impacts to GDEs.	5.3 Appendices 8.2 and 8.3
4	Review current available data on the floristic composition of the Bremer Range vegetation complexes of the Priority 1 Ecological Community (PEC).	5.3 Appendix 3.9
5	Conduct a review of areas outside the above study areas to determine the likelihood of impacts to significant flora or vegetation.	5.3 Appendix 3.9
6	Identify and describe the environmental values of the ironstone ridges of the Bremer Range (*M. aquilonaris* habitat) including assessments on soil profile, topography, geology and hydrological regime. Studies to include: • Soil profile assessments (within sub-populations and outside sub-populations) to measure soil texture/profile, moisture, plant available water, geochemical and physical properties of soil profile; • Geomorphology assessments using landform transects to measure surface geology, topography, elevation, aspect, landscape characteristics and characterise microhabitats; • Hydrological assessments on surface water flows/hydrological regimes of the Bremer Range and influence of ironstone ridge microhabitats; and • Microclimatic assessments to identify microhabitats.	5.3 Appendices 2; 3.1; 8.2; 3.9; 3.10 and 3.11
7	Identify, describe and map area of critical, optimal, and sub-optimal (including occupied and unoccupied areas) habitat for *M. aquilonaris* and provide assessment on the direct and indirect impacts of the proposal on these habitats.	5.3 Appendix 3.11
8	Provide information on the implications of the proposal impacts (direct and indirect) on the genetic diversity and structuring of *M. aquilonaris*. Consideration	5.3

Task No.	Required Work	Section and Page No.
	of the implications of the proposal on population functionality (connectivity etc.) will be provided. Studies to include: • Genetic testing on each sub-population of *M. aquilonaris* to determine genetic diversity and pollination of sub-populations; • If potential direct or indirect impacts to *M. aquilonaris* are proposed, establish demographic monitoring of *M. aquilonaris* sub-populations to measure no. mature/ juvenile plants, height, width, no. flowers/ fruits, seeding/sprouting plants and associated dominant species. Monitoring to determine population structure/ rates of growth/ reproduction and survival, conduct assessments on 'effective population size' (that is plants capable of reproducing), population viability analysis (modelling of probability of plant extinction from direct disturbance) and measure potential indirect impacts to sub-populations; and • If potential direct or indirect impacts to *M. aquilonaris* are proposed, conduct seed viability testing and germination trials.	Appendices 3.2; 3.3; 3.8; 3.11 and 5.3
9	Identify, describe and map area of critical, optimal, and sub-optimal (including occupied and unoccupied areas) habitat for *E. rhomboidea* and *S. bremerense* and provide assessment on the direct and indirect impacts of the Proposal on these habitats.	5.3 Appendices 3.9 and 3.10
10	Include identification of the supporting soil profiles during regional surveys undertaken for *E. rhomboidea* and *S. bremerense*.	5.3 Appendices 2 and 3.9
11	If the Proposal is likely to result in a significant residual impact to *E. rhomboidea* and *S. bremerense*: • Identify soils profiles supporting each species; • Conduct seed collection and germination trials to determine: i. Seed counts, viability and germinability of each species; ii. Alleviation of germination inhibition in the case of *S. bremerense*; iii. Likely effectiveness of propagation and reintroduction of both species in rehabilitation and/or translocation trials; • Identify potential translocation receptor sites for both species; and • Identify rehabilitation soil profile requirements for both species.	5.3 Appendices 2; 3.8; 3.9 and 3.10
12	Provide figure(s) showing the predicted extent of loss of vegetation units and significant flora and vegetation from both direct and indirect impacts including, but not limited to, direct clearing, groundwater abstraction, altered microclimate and microhabitat including hydrology, or dust.	5.3
13	Identify the impact (direct, indirect, secondary and cumulative) of the Proposal on *M. aquilonaris* individuals, sub populations and habitat (including changes to area of occupancy and extent of occurrence) by: • Modelling dust emissions and deposition rates on *M. aquilonaris* populations; and • If potential direct or indirect impacts to *M. aquilonaris* are proposed, identifying potential pollinators for *M. aquilonaris*, including changes to pollinator populations or behaviour, changes to linkages between sub-populations of species pollinated by vectors with short ranges, causing interruptions to gene flow within and between sub-populations.	5.5 Appendix 3.10
14	Identify the impact (direct, indirect, secondary and cumulative) of the Proposal on other significant flora individuals, sub populations and habitat, including *E. rhomboidea* and *S. bremerense*.	5.5 Appendix 3.10
15	Identify any species which may acquire a raised conservation assessment due to predicted impacts of the Proposal.	5.3 and 5.3 Appendices 3.9 and 3.10
16	If potential direct or indirect impacts to *M. aquilonaris* are proposed, conduct a Population Viability Analysis.	5.3; 5.4 and 5.5 Appendix 3.11

Task No.	Required Work	Section and Page No.
17	Discuss, and determine significance of, potential direct, indirect (including downstream) and cumulative impacts to vegetation as a result of the Proposal at a local and regional level.	5.4 and 5.5 Appendix 3.10
18	Demonstrate that all practicable measures have been taken to reduce both the area of the proposed disturbance footprint and the Development Envelope based on progress in the Proposal design and understanding of the environmental impacts.	2.3; 5.3 and 5.6
19	Discuss proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on flora and vegetation.	5.6
20	Discuss management measures, outcomes / objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	5.6 and 5.7
21	Include monitoring, management and mitigation measures for significant flora and vegetation, with specific measures for the Bremer Range Priority Ecological Community, GDEs, *M. aquilonaris, E. rhomboidea* and *S. bremerense.*	5.6 and 5.7
22	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented.	5.6 and 5.7 Appendix 4
23	Prepare a Mine Closure Plan consistent with Department of Mines, Industry Regulation and Safety and EPA Guidelines for Preparing Mine Closure Plans (Department of Mines and Petroleum (DMP), 2015a) which takes into consideration groundwater recovery to support stygofauna habitat.	Appendix 4. Note that guidance has been updated in 2020 and the Mine Closure Plan was developed in accordance with this new guidance.
24	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	5.7
25	Determine and quantify any significant residual impacts by applying the: • Residual Impact Significance Model (page 11 of WA Environmental Offsets Guidelines) for all direct and indirect impacts, including an explanation of how the information and values within the model have been determined. • WA Offset Template - Appendix 1 in the WA Environmental Offsets Guidelines (EPA, 2014), including the provision of supporting information, such as evidence of rehabilitation success.	5.6; 5.7 and 11
26	Where significant residual impacts remain, propose an appropriate offsets package with supporting information to demonstrate consistency with the WA Environmental Offsets Policy (2011) and Guidelines (2014). Spatial data defining the area of significant residual impacts for each environmental value should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).	11
Terrestrial Fauna		
27	A desktop review of available technical reports, relevant databases and spatial data to assess the potential for presence of significant fauna, fauna assemblages, habitats and short-range endemic (SRE) invertebrate fauna species, using EPA guidance.	6.3 Appendices 5.1 and 5.2
28	Level 2 surveys for both vertebrate and SRE invertebrate fauna within both the Mine and Haul Road Development Envelopes, following EPA guidance.	6.3 Appendices 5.1 and 5.2
29	Targeted surveys for significant fauna identified by desktop studies as potentially occurring in the development envelopes, in accordance with EPA guidance.	6.3 Appendices 5.1 and 5.2
30	Produce maps and tables showing and quantifying the extents of fauna habitats and the expected impacts to those habitats in absolute terms and as proportions of	6.3

Task No.	Required Work	Section and Page No.
	total development envelope areas. Including detailed habitat descriptions that consider habitat use by both significant fauna and fauna assemblages.	
31	Assess the likelihood of the habitats to support SRE invertebrate species. Provide figures clearing showing impact to SRE habitat.	6.3 Appendices 5.1 and 5.2
32	Assess whether any SREs or other significant terrestrial invertebrate species would be likely to be restricted to the development envelopes or, if this cannot be demonstrated, that such species have been adequately surveyed for outside of the development envelopes.	6.3 Appendices 5.1 and 5.2
33	Provide justification that completed fauna surveys are relevant, representative of the development envelopes, provide suitably current information on populations and locations of fauna of significance and have been carried out using methods consistent with EPA and Department of Agriculture, Water and the Environment (DAWE) guidance.	6.3 Appendices 5.1 and 5.2
34	For each relevant significant species identified within the development envelopes, provide: • Baseline information on their abundance (including known occurrences), distribution, ecology, and habitat preferences at both the site and regional levels; • Information on the conservation value of each fauna habitat type from a local and regional perspective, including the percentage representation of each habitat type on site in relation to its local extent; and • Maps illustrating the known recorded locations of significant fauna and SRE invertebrates in relation to the proposed disturbance and areas to be impacted.	6.3 Appendices 5.1 and 5.2
35	Identify potential pollinators that may be critical to the successful pollination of flora species with high conservation ranking (Threatened Flora, Priority 1 and 2 species) and assess the expected range and habitat of those pollinators.	6.3 Appendix 5.2
36	Assess and identify habitat types that provide important ecological function within the development envelopes (e.g. refugia, important habitat corridors, areas of significance or geological features which may support unique ecosystems), including locations and quantifying the extents of these habitat features.	6.3
37	Assess the extent of direct and indirect disturbance on significant and other fauna species, including amount of habitat and percentages of habitat types to be disturbed or otherwise impacted, to assist in determination of significance of impacts. Information, including maps, will also differentiate habitat on the basis of use if required e.g. breeding habitat, foraging / feeding / dispersal habitat. Consider whether the remaining habitat has adequate carrying capacity.	6.3; 6.4 and 6.5 Appendices 5.1 and 5.2
38	Discuss known existing threats to the species, whether or not attributable to the Proposal, with reference to relevant impacts from the Proposal.	6.3 Appendices 5.1 and 5.2
39	Assess cumulative and fragmentation impacts to the Greater Western Woodlands.	6.4 and 6.5 Appendices 5.1 and 5.2
40	Provide a detailed description of the potential direct, indirect (including downstream) and cumulative impacts to significant and other fauna species within the development envelopes and on a regional scale.	6.4 and 6.5
41	Identify the potential impacts of the Proposal on the potential range and habitat of potential pollinators that may be critical to the successful pollination of flora species with high conservation ranking (Threatened Flora, Priority 1 and 2 species).	6.4 and 6.5
42	Discuss proposed management, monitoring and mitigation and rehabilitation methods to be implemented including an assessment of the effectiveness of the methods, any statutory or policy basis for the methods and demonstrate that the	6.6

Task No.	Required Work	Section and Page No.
	design of the Proposal has addressed the mitigation hierarchy in relation to impacts on fauna.	
43	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented.	6.6 and 6.7 Appendix 4
44	Prepare a Mine Closure Plan consistent with Department of Mines, Industry Regulation and Safety and EPA Guidelines for Preparing Mine Closure Plans (DMP, 2015a) which takes into consideration groundwater recovery to support stygofauna habitat.	Appendix 4. Note that guidance has been updated in 2020 and the Mine Closure Plan was developed in accordance with this new guidance.
45	Demonstrate and document in the ERD how the EPA's objective for this factor will be met.	6.7
46	Determine and quantify any significant residual impacts by applying the: • Residual Impact Significance Model (page 11 of WA Environmental Offsets Guidelines) for all direct and indirect impacts, including an explanation of how the information and values within the model have been determined. • WA Offset Template - Appendix 1 in the WA Environmental Offsets Guidelines (EPA, 2014), including the provision of supporting information, such as evidence of rehabilitation success.	6.6 and 6.7
47	Where significant residual impacts remain, propose an appropriate offsets package with supporting information to demonstrate consistency with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts for each environmental value should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).	11
Subterranean Fauna		
48	Conduct a Level 1 (basic) stygofauna survey of the proposed borefield area in accordance with EPA guidance, including a habitat assessment. Based on the outcomes of the Level 1 (basic) survey, determine if Subterranean Fauna is to be designated as a Key Environmental Factor for this Proposal.	7.3 Appendix 6
49	Conduct Level 2 (detailed) stygofauna surveys if Subterranean Fauna is determined as a Key Environmental Factor as a result of the above assessment.	7.3 Appendix 6
50	Conduct a groundwater investigation to assess hydraulic conductivity and predicted drawdown.	7.3 Appendices 6 and 8.2
51	Present the results of the groundwater investigation, and discuss the potential for direct and indirect impacts to stygofauna and habitat including consideration of altered water regimes as a result of the Proposal.	7.3; 7.4 and 7.5 Appendices 6 and 8.2
52	Conduct a Level 1 (basic) troglofauna surveys of potential mine pit areas in accordance with EPA guidance, including a habitat assessment as part of the desktop study. Based on the outcomes of the Level 1 (basic) survey, determine whether a Level 2 (detailed) survey is required.	7.3 Appendix 6
53	Identify the proposed activities and the potential scale and significance of direct and indirect impacts to subterranean fauna.	7.4 and 7.5 Appendix 6
54	Discuss proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the Proposal has addressed the mitigation hierarchy in relation to impacts on subterranean fauna.	7.5 and 7.6
55	Prepare a Mine Closure Plan consistent with Department of Mines, Industry Regulation and Safety and EPA Guidelines for Preparing Mine Closure Plans (DMP, 2015a) which takes into consideration groundwater recovery to support stygofauna habitat.	Appendix 4. Note that guidance has been updated in 2020 and the Mine Closure Plan was

Task No.	Required Work	Section and Page No.
		developed in accordance with this new guidance.
56	Evaluate the combined direct and indirect impacts to subterranean fauna, after demonstrating how the mitigation has been considered and applied.	7.4; 7.5 and 7.7
57	Discuss proposed management, monitoring and mitigation methods to be implemented to ensure residual impacts (direct and indirect) are not greater than predicted.	7.6 and 7.7
58	If subterranean fauna is present, assess the significance of impacts to subterranean fauna.	7.3; 7.4 and 7.5
59	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	7.7
60	Determine and quantify any significant residual impacts by applying the: • Residual Impact Significance Model (page 11 of WA Environmental Offsets Guidelines) for all direct and indirect impacts, including an explanation of how the information and values within the model have been determined. • WA Offset Template - Appendix 1 in the WA Environmental Offsets Guidelines (EPA, 2014), including the provision of supporting information, such as evidence of rehabilitation success.	7.6 and 7.7
61	Where significant residual impacts remain, propose an appropriate offsets package with supporting information to demonstrate consistency with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts for each environmental value should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).	11
Terrestrial Environmental Quality		
62	Undertake a tailings characterisation study including testing for physicochemical parameters and the potential concentration of heavy metals, to determine if tailings seepage has the potential to contaminate the terrestrial environment, taking into account assessment methods and assessment guideline values recommended in the National Environment Protection (Assessment of Site Contamination) Measure 1999. The study will include the following if appropriate: • Bulk chemical analysis, including reduced inorganic sulphur and carbon contents; • Geochemical testing of representative tailings samples; • Long-term leaching tests (static and kinetic).	8.3 Appendix 7.1
63	Provide a Tailings Storage Facility (TSF) design (at an appropriate level of detail). If the tailings characterisation study identifies that tailings seepage has the potential to contaminate the terrestrial environment then a Detailed TSF Design Report will be developed in accordance with: • DMPWA (now Department of Mines, Industry Regulation and Safety (DMIRS)) 'Code of Practice, Tailings Storage Facilities in Western Australia (DMP, 2013a)'; • DMPWA 'Guide to the preparation of a design report for tailings storage facilities (DMP, 2015b)'; and • ANCOLD 2019 'Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure (ANCOLD, 2019).	8.3 Appendix 7.3 Note that ANCOLD guidance has been updated in 2019 and TSF design was developed in accordance with this new guidance.
64	Undertake a waste rock characterisation study to determine if leaching has the potential to contaminate the terrestrial environment. The study will include the following if appropriate: • Bulk chemical analysis, including reduced inorganic sulphur and carbon contents; • Classification of waste rock materials into sulfidic and non-sulfidic categories; and • Geochemical and geotechnical testing of representative waste rock samples.	8.3 Appendix 7.2

Task No.	Required Work	Section and Page No.
65	If the potential for contamination is identified in the tailings and waste rock characterisation studies, undertake an investigation to determine what effect the Proposal will have on terrestrial environmental quality. This investigation is to include: • A hydrogeological assessment of the site; • A water balance assessment, maximising process water recovery; • Groundwater and surface water physical-chemical characterisation; and • An assessment of seepage on any water courses.	8.3 and 9.3 Appendices 8.1 and 8.2
66	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	8.6
67	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented.	8.6 Appendix 4
68	An Interim Mine Closure Plan is to be developed to address significant impacts in accordance with Guidelines for Preparing Mine Closure Plans WA (DMP and EPA, 2015). The Plan is to include: • Mine waste characterisation; • Specific mine closure learnings from other comparable sites (comparable in terms of environmental setting, geochemistry and climate); • Proposed methods of closure (capping methods) for TSF and waste rock dumps; and • How a 'walk away' sustainable mine closure solution will be achieved for all aspects of the operation such that there will not be unacceptable liability to the State or future land owners.	Appendix 4. Note that guidance has been updated in 2020 and the Mine Closure Plan was developed in accordance with this new guidance.
69	Demonstrate and document how the EPA's objective for this factor can be met.	8.7
70	Determine and quantify any significant residual impacts by applying the: • Residual Impact Significance Model (page 11 of WA Environmental Offsets Guidelines) for all direct and indirect impacts, including an explanation of how the information and values within the model have been determined. • WA Offset Template - Appendix 1 in the WA Environmental Offsets Guidelines (EPA, 2014), including the provision of supporting information, such as evidence of rehabilitation success.	8.6 and 8.7
71	Where significant residual impacts remain, propose an appropriate offsets package with supporting information to demonstrate consistency with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts for each environmental value should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).	11
Inland Waters		
72	Develop a conceptual model to characterise the groundwater and surface water hydrology.	9.3 Appendices 8.1 and 8.2
73	Assess the likely impacts to surface run-off and lateral through-profile drainage and the implications this may have for supporting vegetation (i) on the margins of excavations and (ii) downstream of infrastructure developed.	9.3 Appendix 8.1
74	Identify areas of potential sheet flow of surface water and assess the likely impacts associated with interruptions to sheet flow.	9.3 Appendix 8.1
75	Undertake desktop and on-site investigations to identify potential water supply sources. Undertake analytical and/or numerical modelling to estimate sustainable yields and design the mine water supply.	9.3 Appendix 8.2
76	Conduct a TSF design review to identify potential losses of water via seepage.	9.3

Task No.	Required Work	Section and Page No.
		Appendices 7.4 and 8.2
77	Undertake a tailings characterisation study to determine if tailings seepage has the potential to contaminate the terrestrial environment.	9.3 and 9.4 Appendix 7.1
78	Undertake a waste rock characterisation study to determine if tailings seepage has the potential to contaminate the terrestrial environment.	9.3 and 9.4 Appendix 7.2
79	If the potential for contamination is identified in the tailings and waste rock characterisation studies, undertake an investigation to characterise hydrogeological processes within the development envelopes and determine what effect the Proposal will have on surface and groundwater quality.	9.3; 9.4 and 9.5 Appendices 8.1 and 8.2
80	Develop a surface water and groundwater monitoring programme to establish pre-development hydrological regimes, detect impacts due to groundwater abstraction or mine activity, and inform management response.	9.6 Appendix 8.1
81	Analyse, assess and discuss potential surface water and groundwater impacts including: • Changes in groundwater levels and surface water flows associated with implementation of the Proposal; • The nature, extent and duration of impacts; • Impacts on environmental values of any sensitive receptors; • Impacts on the quality of the water resources; and • Impacts on any other identified users of the resource.	9.4 and 9.5 Appendices 8.1 and 8.2
82	Describe the proposed monitoring, management and mitigation measures to be implemented, including an assessment of their effectiveness, at the design and operations stages to demonstrate that all reasonable and practicable avoidance and mitigation measures will be taken to ensure residual impacts and risks are acceptable.	9.6
83	Discuss closure and rehabilitation management measures, outcomes / objectives to be achieved.	9.6 Appendix 4
84	An Interim Mine Closure Plan is to be developed to address specific impacts in accordance with Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015).	Appendix 4. Note that guidance has been updated in 2020 and the Mine Closure Plan was developed in accordance with this new guidance.
85	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	9.7
86	Determine and quantify any significant residual impacts by applying the: • Residual Impact Significance Model (page 11 of WA Environmental Offsets Guidelines) for all direct and indirect impacts, including an explanation of how the information and values within the model have been determined. • WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014), including the provision of supporting information, such as evidence of rehabilitation success.	9.6 and 9.7
87	Where significant residual impacts remain, propose an appropriate offsets package with supporting information to demonstrate consistency with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts for each environmental value should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).	11

EXECUTIVE SUMMARY

The Proposal is to develop the Medcalf Project (Proposal) which is located in the Bremer Range, Lake Johnston region of Western Australia, approximately 470 km east south-east of Perth (Figure ES1).

Figure ES1: Regional location of the Proposal

KEY PROPOSAL CHARACTERISTICS

Audalia has referred to the Environmental Protection Authority's (EPA's) *Instructions on how to define the key characteristics of a proposal* (EPA, 2016b) - which focuses on proposals for the purposes of Environmental Impact Assessment under Part IV of the *Environmental Protection Act 1986* (EP Act). In accordance with these instructions, a summary of the Proposal is provided in Table ES1 and the key proposal elements (e.g. development, action, activities or processes) which are likely to cause an impact on the environment are summarised in Table ES2.

Table ES1: Key Characteristics of the Proposal

Proposal Title	Medcalf Project
Proponent Name	Audalia Resources Limited
Short Description	The Proposal is to develop a vanadium, titanium and iron mining operation, approximately 100 km southwest of Norseman, WA. The Proposal includes the development of three or four open mine pits, beneficiation plant, tailings storage facility (TSF), private haul road, road train transfer area and associated infrastructure such as laydown areas, borrow and gravel pits, groundwater bores, workshops and accommodation camp.

Table ES2: Indicative location and proposed extent of physical and operational elements

Element	Indicative Location	Proposed Extent
Physical Elements		
Mine and associated infrastructure	Figure 2 and Figure 3	Clearing of no more than 300 ha within the 898 ha Mine Development Envelope (Mine DE)
Haul Road and associated infrastructure	Figure 2, Figure 4 and Figure 5	Clearing of no more than 350 ha within the 1,633 ha Haul Road Development Envelope (Haul Road DE)
Significant flora	Figure 57 and Figure 66	Clearing of no more than: • 1.51 ha of *M. aquilonaris* sub-optimal habitat • 0.4 ha of *Eucalyptus rhomboidea* population extent • 21 ha of *Stenanthemum bremerense* population extent
Operational Elements		
Tailings disposal	Figure 3	Disposal of no more than 7.2 Million tonnes of tailings into the TSF
Groundwater supply borefield	Figure 3	Abstraction of no more than 1.2 GL per annum, of which no more than 0.8 GL per annum is to be abstracted from the mine site borefield

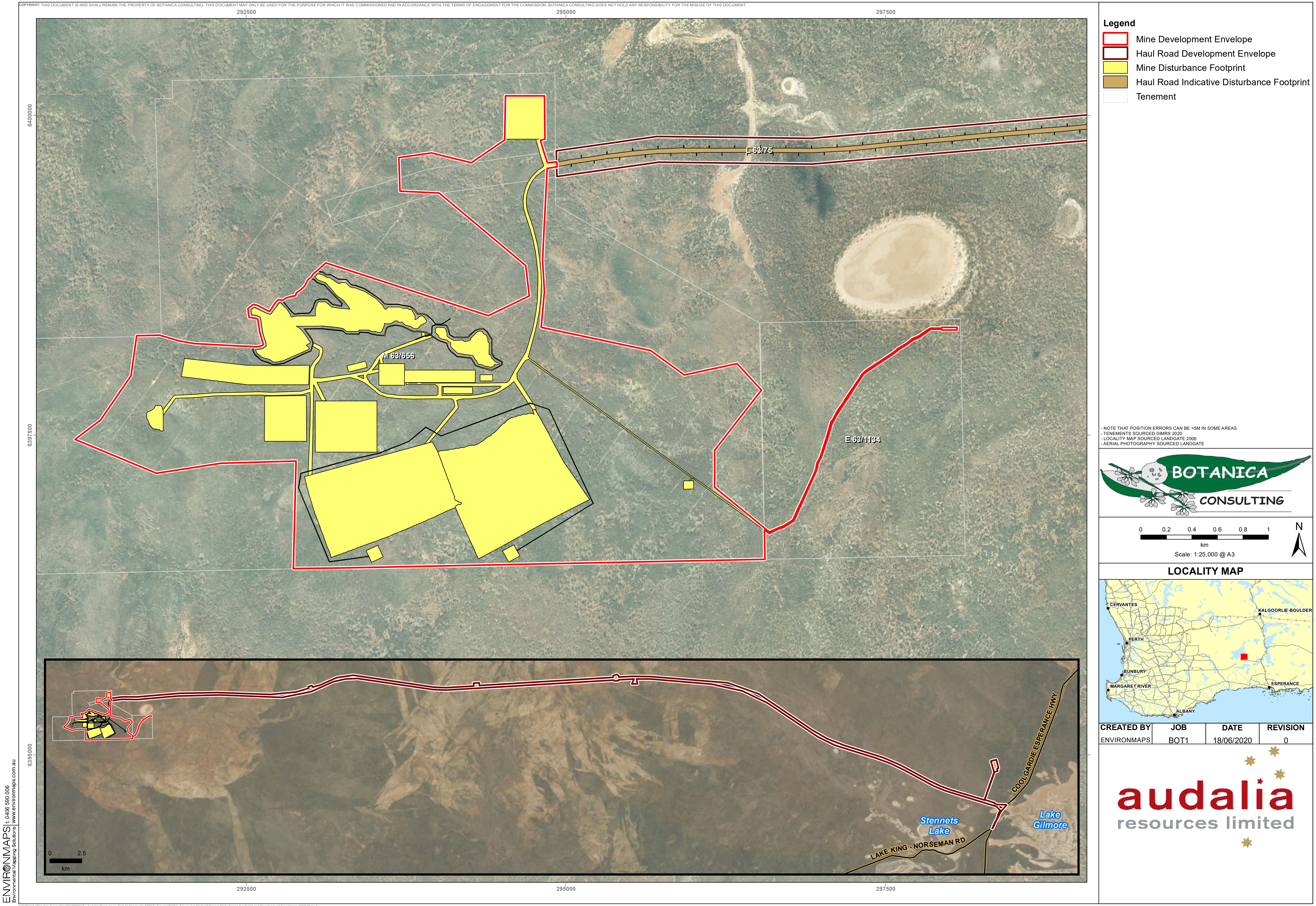


Figure ES2: Development Envelopes

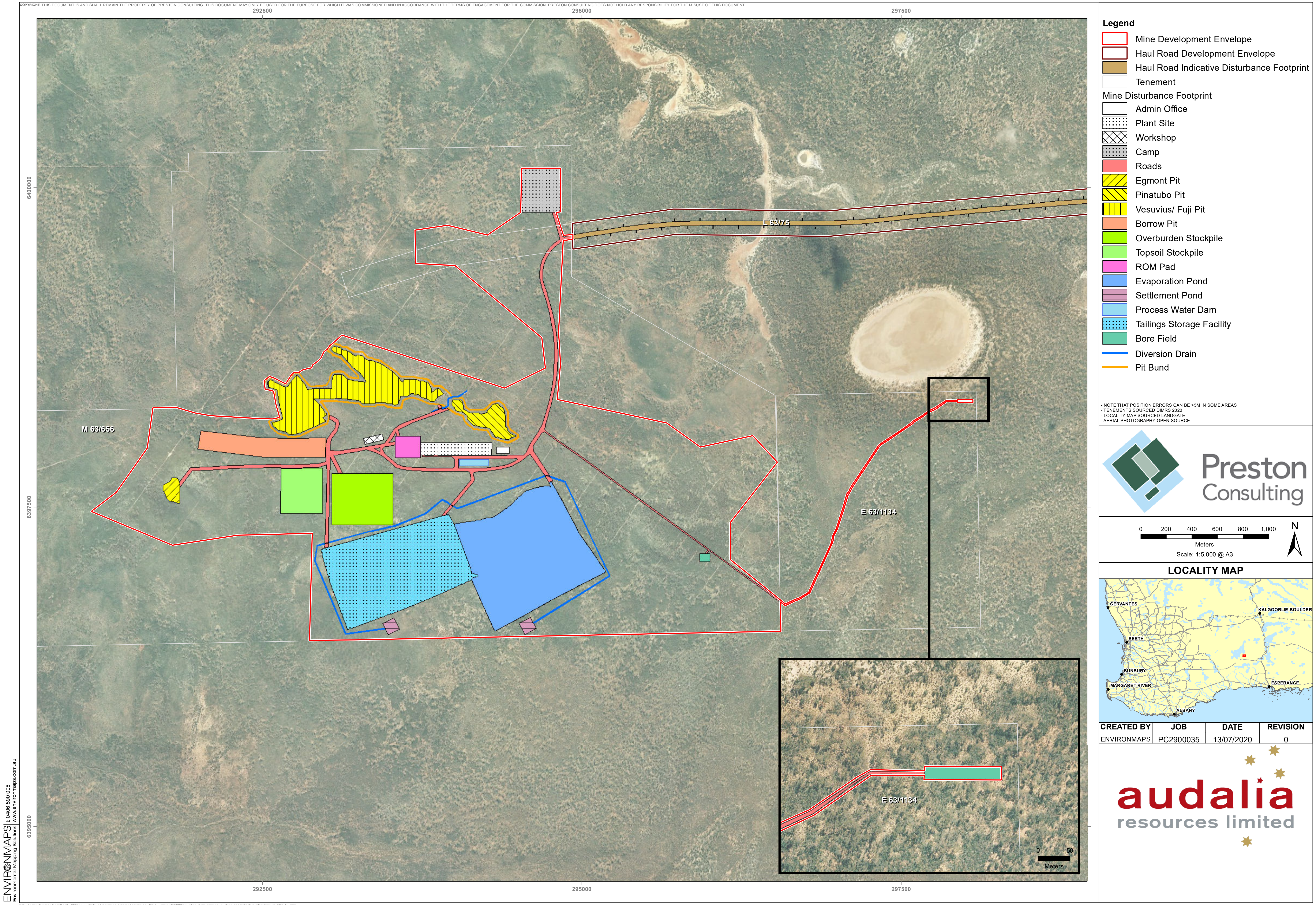


Figure ES3: Mine DE and indicative infrastructure

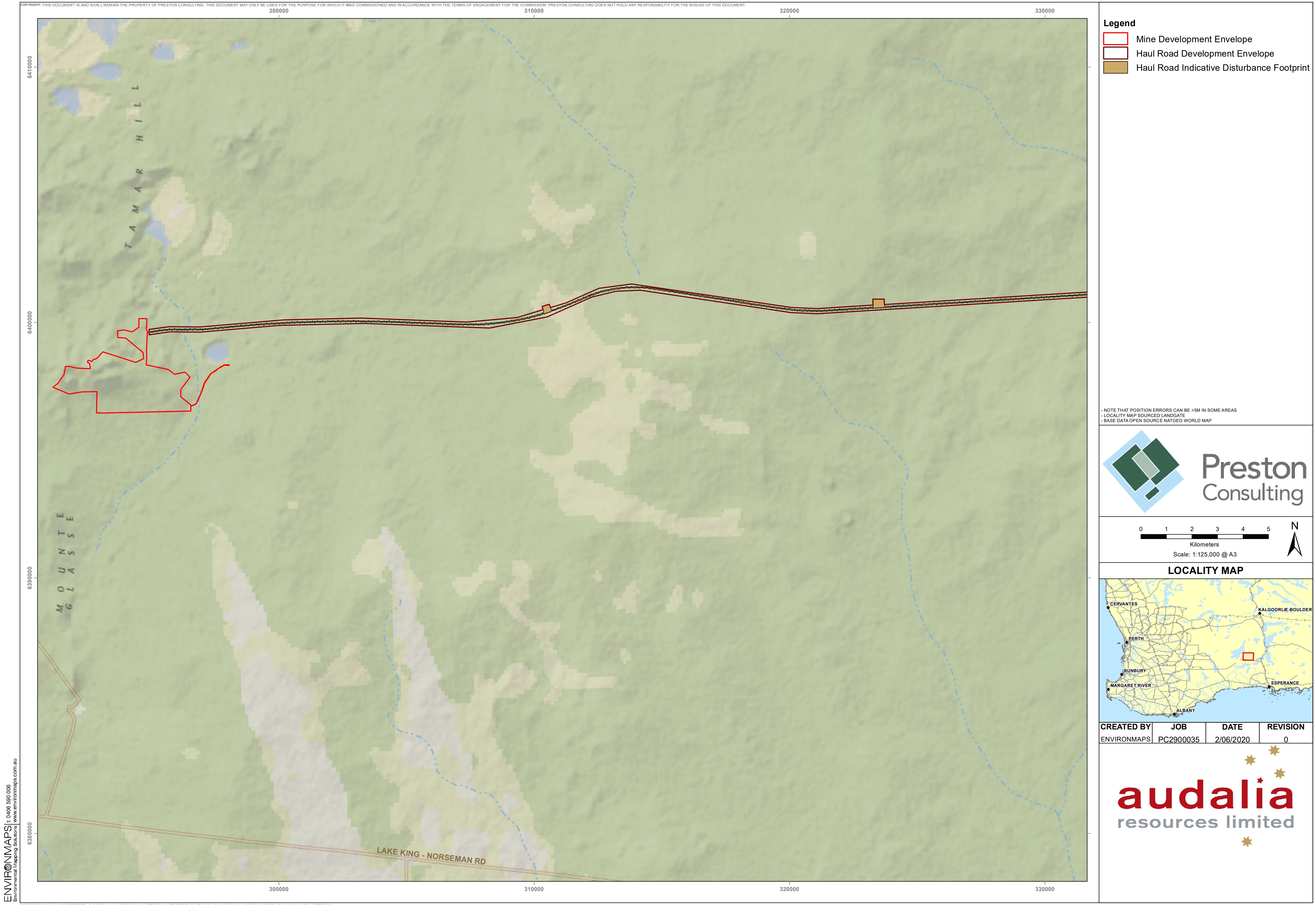


Figure ES4: Haul Road DE and indicative layout (1 of 2)

Legend

- Mine Development Envelope
- Haul Road Development Envelope
- Haul Road Indicative Disturbance Footprint

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- LOCALITY MAP SOURCED LANDGATE
- BASE DATA OPEN SOURCE NATGEO WORLD MAP

Preston Consulting

0 1 2 3 4 5
Kilometers
Scale: 1:125,000 @ A3
N

LOCALITY MAP

CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900035	2/06/2020	0

audalia resources limited

ENVIRONMAPS Environmental Mapping Solutions t 0406 590 006 www.environmaps.com.au

Figure ES5: Haul Road DE and indicative layout (2 of 2)

KEY ENVIRONMENTAL FACTORS

The EPA identified the following preliminary key environmental factors for this Proposal:

- Flora and Vegetation;
- Terrestrial Fauna;
- Subterranean Fauna;
- Terrestrial Environmental Quality; and
- Inland Waters.

Table ES3 summarises relevant information on the potential impacts, mitigation and outcomes for each of the preliminary key environmental factors identified by the EPA. The appendices provide supporting studies and investigations undertaken to inform this Environmental Review, the key elements of which are included in this document.

Table ES3: Summary of the Environmental Review

Flora and Vegetation	
EPA objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA Policy and Guidance** • Statement of Environmental Principles, Factors and Objectives (EPA, 2020a) • Environmental Factor Guideline for Flora and Vegetation (EPA, 2016c) • Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016d) • EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA, 2016a) • EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2020c) • Environmental Protection Bulletin 20 - Protection of naturally vegetated areas through planning and development (EPA, 2013) • Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006) **Other Policy and Guidance** • WA Environmental Offsets Guidelines (EPA, 2014) • WA Environmental Offsets Policy 2011 (EPA, 2011) • *M. aquilonaris* Interim Recovery Plan 2010-2014. Interim Recovery Plan No. 303 (Department of Environment and Conservation (DEC), 2010b)

Potential impacts	• Up to 650 ha clearing of vegetation, which lies within the Great Western Woodlands region and within the 'pathway' of the Gondwanalink project, including associated fragmentation impacts
	• Disturbance of 1.51 ha of *M. aquilonaris* sub-optimal habitat within the critical habitat boundary
	• Disturbance of *M. aquilonaris* sub-population 1f which has a single historic record but no current individuals present.
	• Disturbance and indirect impacts to *M. aquilonaris* pollinator habitat
	• Disturbance of 768 *Eucalyptus rhomboidea* (P4) individuals and 0.4 ha of sub-population extent
	• Disturbance of 2,049 *Stenanthemum bremerense* (P4) individuals and 21 ha of population extent
	• Disturbance of:
	  ○ 10,001 *Acacia mutabilis* subsp. *stipulifera* individuals
	  ○ 876 *Hakea pendens* individuals
	  ○ 1,150 *Teucrium diabolicum* individuals
	• Up to 309 ha of disturbance of the Proposed Bremer Range Nature Reserve
	• Up to 285 ha of disturbance of the Bremer Range Vegetation Complexes Priority Ecological Community (PEC)
	• 544 ha of disturbance across five of the locally significant floristic communities
	• Reduction in vegetation health as a result of:
	  ○ Excessive dust
	  ○ Changes to hydrological regimes

	○ Hydrocarbon or saline water spills ○ Establishment or spread of weed species / populations ○ Increased fire risks
Mitigation	**Avoid**: Avoidance measures are considered to be critical to the Proposal given the significant ecological values of the area. Audalia conducted extensive flora and vegetation surveys of the areas surrounding the proposed mine and haul road, and have utilised this information to conduct multiple mine planning and haul road design revisions. This avoidance process resulted in the final boundaries of the DEs presented in this ERD, which now avoid the following values identified during the surveys: • All current *M. aquilonaris* individuals • All current *M. aquilonaris* areas of occupancy (sub-populations) • All *M. aquilonaris* optimal habitat • All catchment areas upslope of current *M. aquilonaris* areas of occupancy (sub-populations) • All *Acacia hystrix* subsp. *continua* (P1) records • All *Bossiaea flexuosa* (P3) records • All *Brachyloma stenolobum* (P1) records • All *Eucalyptus pterocarpa* (P3) records • All *Microcybe* sp. Windy Hill (G.F. Craig 6583) (P3) records • Locally significant floristic communities HS-MWS1 and HS-MWS3 • More than 96% of *Acacia mutabilis* subsp. *stipulifera* (P3) records within the study areas • More than 79% of *Eucalyptus rhomboidea* (P4) records within the study areas • More than 40% of *Hakea pendens* (P3) records within the study areas • More than 88% of *Stenanthemum bremerense* (P4) records within the study areas • More than 87% of *Teucrium diabolicum* (P3) records within the study areas • More than 58% of all locally significant floristic communities **Minimise**: • Implement industry best practice management measures for flora and vegetation • Ensure ground disturbance does not exceed the limits proposed in the Key Proposal Characteristics • Obtain and comply with Part V EP Act and *Mining Act 1978* (Mining Act) approvals • Conduct additional significant flora searches of final proposed mine and infrastructure disturbance footprints • Prepare and implement a Mine and Infrastructure Plan • Implement additional ground disturbance measures for any ground disturbance within *M. aquilonaris* critical habitat, and *Eucalyptus rhomboidea* or *Stenanthemum bremerense* population boundaries • Implement the Dust Control Management Strategy provided in Appendix 10 • Cease mining activities at the Vesuvius mine pit if dust deposition reaches 4.5 g/m^2 at the boundary of *M. aquilonaris* sub-populations during the key growth period of August to November • Ensure all surface water crossings are designed to minimise the potential for erosion or sedimentation of downstream vegetation • Implement measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes • Implement additional controls upslope of *M. aquilonaris* critical habitat, or *Eucalyptus rhomboidea* or *Stenanthemum bremerense* population boundaries • Prepare and implement a Significant Flora Monitoring Programme • Conduct an additional *M. aquilonaris* pollinator survey during peak flowing season **Rehabilitate:** • All infrastructure will be removed from site • Any residual salt within the evaporation ponds will be excavated and either placed in the bottom of the mine pit, in a borrow pit or taken off site • All disturbance areas apart from the mine pit and TSF slopes will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated • All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed introduction • Seed will be collected from any *M. aquilonaris, Eucalyptus rhomboidea* or *Stenanthemum bremerense* individuals recorded within the proposed ground disturbance area during the pre-clearance survey

	• *Eucalyptus rhomboidea, Stenanthemum bremerense* and *Hakea pendens* germination trials are to be conducted during the life of the Proposal to target the successful establishment of these species into rehabilitation areas
	• Other Priority Flora will be included in the rehabilitation seed mix if seed is available and germination is likely to be successful
	• Flowering plants will be included in seeding to ensure pollinator habitat is adequately reinstated
	• All depressions will be shaped to prevent the formation of new semi-permanent water sources
	• All surface water drainage diversions will be rehabilitated to a natural form
	• All surface water crossings will be reinstated by removing drainage infrastructure and reshaping as required
	Offset:
	• Provision of funding and support (to address any DMIRS concerns) for the development of a conservation reserve or other protected area for *M. aquilonaris* critical habitat extents (at a minimum)
	• Revegetation of previously disturbed vegetation within the *M. aquilonaris* critical habitat boundary (access tracks)
	• On ground management within *M. aquilonaris* critical habitat and local *Eucalyptus rhomboidea* and *Stenanthemum bremerense* populations
	• Ongoing *M. aquilonaris*, *Eucalyptus rhomboidea* and *Stenanthemum bremerense* research:
	  o Ongoing germination trials
	  o Annual plant counts
	  o Sub-population health monitoring
	  o Rehabilitation trials
	• Translocation of *Eucalyptus rhomboidea* individuals to rehabilitation areas
	• Translocation of *Stenanthemum bremerense* individuals to rehabilitation areas
	• On-ground management of the Proposed Bremer Range Nature Reserve and Bremer Range Vegetation Complexes PEC

Outcome	The EPA's environmental objective for this factor is "to protect flora and vegetation so that biological diversity and ecological integrity are maintained". In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2020a). Audalia has incorporated extensive avoidance and minimisation measures into the Proposal design. The Proposal that was originally referred to the EPA under Section 38 of the EP Act included the disturbance of *M. aquilonaris*; a Threatened Flora taxon pursuant to the BC Act. Based on the mine plan that was referred, a predicted 24% of known *M. aquilonaris* individuals would have been disturbed. Audalia has commissioned numerous regional searches for this species and no other populations have been found during these surveys, which has confirmed that the sub-populations at Medcalf are significant for the survival of this species. Given the restricted range and small sub-populations of *M. aquilonaris,* Audalia has substantially altered their mine plan and the Mine DE to avoid mining within or adjacent to the *M. aquilonaris* sub-populations, and minimising indirect impacts. This has carried significant economic implications, as the highest grade ore resource is located within and adjacent to the sub-populations. Audalia has also significantly reduced the extent of the Mine DE to exclude Priority Flora populations as much as practicable and will ensure that the final design of the Proposal further reduces the potential impacts to Priority Flora. Despite the measures described above, residual impacts to three significant flora species (*M. aquilonaris, Eucalyptus bremerense* and *Stenanthemum bremerense*), the proposed Bremer Range Nature Reserve and the Bremer Range Vegetation Complexes PEC are considered to remain significant once mitigation measures are implemented. Offset measures are proposed to counterbalance these residual impacts to ensure that the EPA objective can be met. These offset measures will be reviewed and refined during the assessment process through discussions with DBCA and EPA Services to ensure they adequately counterbalance the residual impacts.
Terrestrial Fauna	
EPA objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA Policy and Guidance** • Statement of Environmental Principles, Factors and Objectives (EPA, 2020a) • Environmental Factor Guideline for Terrestrial Fauna (EPA, 2016e)

	• Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (EPA, 2016f) • Technical Guidance: Terrestrial Fauna Surveys (EPA, 2016g) • Technical Guidance: Sampling of Short Range Endemic Invertebrate Fauna (EPA, 2016h) • EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA, 2016a) • EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2020c). **Other Policy and Guidance** • WA Environmental Offsets Guidelines (EPA, 2014) • Survey Guidelines for Australia's Threatened Birds (Department of the Environment, Water, Heritage and the Arts (DEWHA), 2010) • Survey Guidelines for Australia's Threatened Mammals (DEWHA, 2011) • National Recovery Plan for Malleefowl (*Leipoa ocellata)* (Benshemesh, 2007) • Chuditch (*Dasyurus geoffroii*) National Recovery Plan (DEC, 2012) • Threat abatement plan for predation by feral cats (Department of the Environment, 2015) • Threat Abatement Plan for competition and land degradation by rabbits. Commonwealth of Australia (DotEE, 2016) • Threat Abatement Plan for Predation by the European Red Fox (DEWHA, 2008)

Potential impacts	• Up to 650 ha clearing of fauna habitat, which lies within the Greater Western Woodlands region and within the 'pathway' of the Gondwanalink project, including associated fragmentation impacts
	• Death or injury of fauna due to vehicle strike or earthmoving equipment
	• Fauna entrapment in evaporation pond, TSF, excavations and behind fences
	• Increased predation or competition from introduced fauna
	• Altered movements and behaviour of fauna due to haul road
	• Increase fire risks as a result of machinery sparks, cigarettes and other sources
	• Alterations to fauna behaviour (including feeding or breeding characteristics) as a result of excessive dust, light or noise emissions
	• Reduction in habitat health as a result of:
	  o Establishment or spread of weed species/populations
	  o Excessive dust
	• Up to 350 ha of clearing of potential Malleefowl habitat
	• Death or injury and / or destruction of Malleefowl mounds during clearing and construction
	• Clearing of up to 5.7 ha of *M. aquilonaris* pollinator habitat
	• Clearing of up to 300 ha of habitat for potential SREs within the Mine DE and up to 350 ha within the Haul Road DE

Mitigation	**Avoid**: The key avoidance mechanism implemented by Audalia was the design of the development envelopes to avoid key environmental features. Audalia has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid the majority of *M. aquilonaris* pollinator habitat, which was excluded from development envelopes by relocating the mine pits. **Minimise**: • Implement industry best practice management measures for terrestrial fauna • Obtain and comply with Part V EP Act and Mining Act approvals • Implement the Dust Control Management Strategy provided in Appendix 10 • Prepare and implement an Introduced Fauna Management Plan • Conduct pre-clearance surveys for active Malleefowl mounds • Conduct a detailed SRE survey within the DEs and surrounds • Conduct an additional *M. aquilonaris* pollinator survey during peak flowing season **Rehabilitate**: • All infrastructure will be removed from site • Any residual salt within the evaporation ponds will be excavated and either placed in the bottom of the mine pit, in a borrow pit or taken off site. • All disturbance areas apart from the mine pit and TSF slopes will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated • All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed introduction • Flowering plants will be included in seeding to ensure pollinator habitat is adequately reinstated • All depressions will be shaped to prevent the formation of new semi-permanent water sources

	• All surface water drainage diversions will be rehabilitated to a natural form • All surface water crossings will be reinstated by removing drainage infrastructure and reshaping as required
Outcome	The EPA's environmental objective for this factor is "protect terrestrial fauna so that biological diversity and ecological integrity are maintained." In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2016f). Audalia has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however some direct and indirect impacts to terrestrial fauna are unavoidable. The Proposal will result in the direct disturbance of up to 650 ha of fauna habitat, which includes habitat that may be utilised by significant fauna. All of these habitats are widely distributed throughout the region and species that potentially use the Proposal area have relatively wide ranging distributions and/or will persist in adjoining unaffected areas given the presence to extensive areas of similar habitat nearby. The Proposal will have direct and indirect impacts on pollinator habitat for *M. aquilonaris*, which is considered under the Flora and Vegetation factor (Section 5). In summary, the resultant potential impacts to terrestrial fauna are not expected to be significant given that: • The Proposal is located in a remote area with only minor disturbance associated with historic mining exploration • Only a small portion of each mapped fauna habitat type will be impacted • SRE species are unlikely to be restricted to the proposed disturbance footprint (to be confirmed during detailed field surveys currently underway) • Groundwater abstraction will be assessed by DWER and managed under 5C Licences issued under the RIWI Act • Other indirect impacts are not expected to be significant or are easily mitigated • Rehabilitation will occur as described in the MCP to be assessed under the Mining Act The implementation of the proposed mitigation is expected to ensure that no significant residual impacts occur. Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor.
Subterranean Fauna	
EPA objective	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA Policy and Guidance** • Statement of Environmental Principles, Factors and Objectives (EPA, 2020a) • Environmental Factor Guideline for Subterranean Fauna (EPA, 2016i) • Technical Guidance: Subterranean Fauna Survey (EPA, 2016j) • Technical Guidance: Sampling Methods for Subterranean Fauna (EPA, 2016k) Other relevant guidance documents for subterranean fauna are listed below: • Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Commonwealth of Australia, online resource, 2018) • Australian Groundwater Modelling Guidelines. Waterlines Report (Barnett et al., 2012) • Western Australia Water in Mining Guideline. Water licensing delivery report series. Report No. 12 (Department of Water (DoW), 2013) • State Water Quality Management Strategy Document No. 6. (Government of WA, 2004); and • *Rights in Water and Irrigation Act 1914* (RIWI Act)
Potential impacts	• Excavation of troglofauna habitat within the proposed mine pits • Alteration of habitat characteristics due to mining and seepage from TSF and evaporation ponds
Mitigation	**Avoid**: • Mine dewatering will not be required • Groundwater abstraction will not occur within the surficial, fresh or moderately-saline aquifers within and immediately adjacent to the Lefroy Palaeochannel **Minimise**: • Limit abstraction within the mine borefield to 0.8 GL/yr in the Key Characteristics Table • Ensure the excavation of the proposed mine pits is the minimum required to ensure safe and mining operations • Verify that troglofauna species and habitats are not restricted to the mine pits, TSF or Evaporation Ponds

	• Design, construct and operate the TSF and Evaporation Ponds in accordance with approvals required under the Mining Act and Part V of the EP Act
Outcome	The EPA's environmental objective for this factor is "protect subterranean fauna so that biological diversity and ecological integrity are maintained." Audalia has commissioned a third round of troglofauna surveys to verify that troglofauna habitat and populations are not constrained to the mine pits, TSF or evaporation ponds. Once this position is verified then Audalia considers that the EPA's environmental objective for this factor can be met, as the excavation or indirect impact of a relatively small portion of the available habitat would be unlikely to threaten the maintenance of biological diversity and ecological integrity. This information will be provided to the Department of Water and Environmental Regulation (DWER) as soon as it is available (expected September / October 2020), and prior to their assessment.
Terrestrial Environmental Quality	
EPA objective	To maintain the quality of land and soils so that environmental values are protected.
Policy and guidance	**EPA Policy and Guidance** • Statement of Environmental Principles, Factors and Objectives (EPA, 2020a) • Environmental Factor Guideline for Terrestrial Environmental Quality (EPA, 2016l) **Other Policy and Guidance** • Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Commonwealth of Australia, online resource, 2018) • Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2020d) • Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015) • "Appendix B: Potentially contaminating industries, activities and land uses" in Assessment and management of contaminated sites: Contaminated sites guidelines (Department of Environment Regulation (DER), 2014) • Global Acid Rock Drainage Guide (International Network for Acid Prevention, 2014) • Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure (Australian National Committee on Large Dams, 2012) • Identification and investigation of acid sulphate soils and acidic landscapes (DER, 2015) • Erosion and sediment control on unsealed roads. A field guide for erosion and sediment control maintenance practices (NSW Office of Environment and Heritage, 2012)
Potential impacts	• Discharge of up to 45 kL/day of treated sewage via irrigation • Disposal of putrescible waste at the landfill. Contamination of soil from seepage from the TSF • Contamination of soil from seepage from the TSF or spillage of tailings • Hydrocarbon spills causing contamination • Seepage, leaks or spills of saline water or desalination brine • Erosion from active or rehabilitated structures spreads sediment into terrestrial environment • Disturbance of Acid Sulphate Soils (ASS)
Mitigation	**Avoid**: • Waste rock dump impacts avoided by utilising mined waste rock materials in the construction of embankments for the TSF and Evaporation Ponds • On-site contamination risks from the chemical processing of ore avoided by conducting this offshore • Disturbance of Potential ASS avoided by constructing a causeway at 'crossing 1' without excavating in-situ soils **Minimise**: • Obtain and comply with Works Approval and Licence issued under Part V of the EP Act • Obtain and comply with a Mining Proposal issued under the Mining Act • Implement measures to minimise the risk and impact of hydrocarbon spills • All road surface water crossings will be designed to minimise the potential for erosion **Rehabilitate**: • Rocky and blocky material from laterite/limonite deposits, and topsoils will be retained separately from other subsoil materials and used for erosion protection during rehabilitation • All disturbance areas (except mine pits) will be landformed to slopes consistent with surrounding landforms, respread with topsoil and rehabilitated

	• Saprolite materials will not be used as the outer surface for built structures • Rehabilitation slopes above ten degrees will be sheeted with competent materials to provide erosion protection based on erosion testwork and modelling of representative topsoils • Rehabilitation areas will be seeded with local native species • Research will be conducted into how to establish and maintain conservation significant species in site rehabilitation
Outcome	The EPA's environmental objective for this factor is "to maintain the quality of land and soils so that environmental values are protected" (EPA, 2016l). In the context of this objective: "terrestrial environmental quality" is defined as the chemical, physical, biological and aesthetic characteristics of soils (EPA, 2016l). The specific environmental values to be protected are 'the ecosystem health values that the soils support, including biodiversity and seed banks'. The Proposal is not expected to significantly impact terrestrial environmental quality. Tailings seepage is benign and fresh, and there is saline - hypersaline groundwater throughout the Mine DE and no beneficial users of this resource. Seepage from the TSF and evaporation ponds is not predicted to impact soils other than directly below the infrastructure and leaks and spills of tailings or saline water are able to be managed such that impacts are rare and restricted in extent if they were to occur. Erosion and hydrocarbon spills are able to be mitigated such that significant impacts are unlikely. The key risks to terrestrial environmental quality is pollution from the Process Plant, TSF, RO Plant, evaporation ponds, saline water pipelines, wastewater treatment plant and landfill. The design and operation of all of these items will be regulated under Part V of the EP Act and the Mining Act. The implementation of design and operations mitigation measures, and regulation under Part V of the EP Act and the Mining Act, are expected to ensure that the Proposal does not significantly impact this factor. The EPA objective for this factor is therefore able to be met.
Inland Waters	
EPA objective	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
Policy and guidance	**EPA Policy and Guidance** • Statement of Environmental Principles, Factors and Objectives (EPA, 2020a) • Environmental Factor Guideline for Inland Waters (EPA, 2018a) • EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA, 2016a) • EIA (Part IV Divisions 1 and 2) Procedures Manual 2016 (EPA, 2016c) • WA Environmental Offsets Guidelines (EPA, 2014) **Other Policy and Guidance** • Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Commonwealth of Australia, online resource, 2018) • WA Water in Mining Guideline. Water licensing delivery report series. Report No. 12. (DoW, 2013)
Potential impacts	• Disturbance within the boundary of surface water catchments • Diversion of one drainage line within the Mine DE • Changes to surface water flow regimes • Erosion caused by re-directed concentrated water flows • Sedimentation as a result of scour caused by road drainage • Contamination of surface water flows from spills of hydrocarbons, chemicals, sewage or saline water • 0.56 ha of disturbance within the catchment above *M. aquilonaris* Optimal Habitat • Changes in surface water flow volumes and water balance within unoccupied area of *M. aquilonaris* Optimal Habitat • Abstraction of 0.8 GL/yr from the fractured rock and/or palaeochannel aquifers • Abstraction of 0.4 GL/yr from palaeo-tributary, fractured bedrock and/or surficial aquifers • Drawdown of groundwater around abstraction bores • Localised mounding of groundwater from TSF / evaporation ponds seepage • Leaching of contaminants from the TSF / evaporation ponds into the underlying groundwater • Hydrocarbon and chemical spills causing contamination of groundwater • Leaks or spills of saline water or desalination brine into groundwater
Mitigation	**Avoid**:

	• The selected haul road route generally traverses the upper reaches of catchments, avoiding significant surface water flow crossings • On-site processing is limited to beneficiation, which avoids the significant water demand associated with further onsite processing • Direct impacts to the upslope catchment of *M. aquilonaris* sub-populations have been avoided by relocating the pit boundaries **Minimise**: • Obtain and comply with Works Approval and Licence issued under Part V of the EP Act • Obtain and comply with a Mining Proposal issued under the Mining Act • Obtain a 5C Licence under the RIWI Act if groundwater sources are from a confined or semi-confined aquifer • Implement measures to minimise the risk and impact of hydrocarbon spills • All road surface water crossings will be designed to minimise the potential for erosion and sedimentation of surface waters • Comply with Water Quality Protection Guidelines and guidance notes **Rehabilitate**: • The haul road will either be retained with a new owner agreed to take responsibility, or will be rehabilitated with any watercourse crossing structures removed • The mining area will be landformed, with post-mining drainage constructed to required standards • The mining area will be revegetated with local native species • All infrastructure will be removed • All surface water drainage systems will be reinstated
Outcome	The EPA's environmental objective for this factor is "maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected" (EPA, 2018a). The Proposal has been designed to ensure that hydrological regimes are maintained. GRM (2020b) have proposed the design of creek crossings along the haul road to ensure flows are maintained, and Audalia have committed to implementing these recommendations. The mine will require some diversions of surface water flows however these flow lines are high in the catchment and flow volumes are unlikely to be large through these areas. The drainage diversions are therefore expected to be appropriate for maintaining the hydrological regimes through the Mine DE. Audalia has revised its mine plan to avoid any direct disturbance upslope of any existing *M. aquilonaris* sub-populations, therefore the Proposal will not reduce any surface water flows into these sub-populations. 0.56 ha of direct disturbance will be required upstream of optimal habitat for *M. aquilonaris*, which will reduce the surface water flows into these areas. This reduction in the catchment is considered unlikely to reduce the viability of the optimal habitat, as the sub-populations for this species lie across catchment divides (Figure 63), indicating that the species is unlikely to be reliant on upslope surface water runoff for survival. The Proposal is not expected to significantly impact the quality of groundwater or surface water. Tailings seepage is benign and fresh, and there is saline - hypersaline groundwater throughout the Mine DE and no beneficial users of this resource. Leaks and spills of tailings or saline water are able to be managed such that impacts are rare and restricted in extent if they were to occur. Erosion and hydrocarbon spills are able to be mitigated such that significant impacts are unlikely. The key risks to the quality of inland waters is pollution from the Process Plant, TSF, RO Plant, evaporation ponds, saline water pipelines, wastewater treatment plant and landfill. The design and operation of all of these items will be regulated under Part V of the EP Act and the Mining Act. The implementation of design and operations mitigation measures, and regulation under Part V of the EP Act and the Mining Act, are expected to ensure that the Proposal does not significantly impact this factor. The EPA objective for this factor is therefore able to be met.

HOLISTIC IMPACT ASSESSMENT

The Proposal lies within the Great Western Woodlands; an area of known ecological significance, and intersects with the proposed Bremer Range Nature Reserve and Bremer Range Vegetation Complexes PEC. Several significant flora species were also identified within the Mine Study Area.

Given the above, Audalia incorporated extensive avoidance and minimisation measures into the Proposal design. The Proposal that was originally referred to the EPA under Section 38 of the EP Act included the direct disturbance of *M. aquilonaris*; a Threatened Flora taxon pursuant to the BC Act. Based on the mine plan that was originally proposed and referred to the EPA, a predicted 24% of known *M. aquilonaris* individuals would have been disturbed. Audalia has since commissioned numerous regional searches for this species and no other populations have been found, which has confirmed that the sub-populations at Medcalf are significant for the survival of this species. Given the restricted range and small population of *M. aquilonaris,* Audalia substantially altered their mine plan to avoid mining within or adjacent to the *M. aquilonaris* sub-populations, and minimising indirect impacts. Audalia also significantly reduced the extent of the Mine DE to exclude Priority Flora populations as much as practicable, and will ensure that the final design of the Proposal further reduces the potential impacts to Priority Flora (Table 36). This has carried significant economic implications, as the highest grade ore resource is located within and adjacent to the sub-populations.

There are some potential impacts that require management and monitoring to ensure that the impacts are not significant. Many of these potential impacts are adequately regulated under other legislation:

- TSF and evaporation pond seepage, brine spills and leaks, process plant dust and sewage will be regulated under Part V of the EP Act;
- Mine pit and TSF design, and general environmental management will be regulated through a Mining Proposal assessed under the Mining Act; and
- Closure and rehabilitation will be regulated through a MCP assessed under the Mining Act.

There are some potential impacts however that are expected to require limits or conditions in the Ministerial Statement, including:

- Limits on total disturbance within each development envelope;
- Limits on the disturbance of *M. aquilonaris* sub-optimal habitat;
- Limits on the disturbance of *Eucalyptus rhomboidea* and *Stenanthemum bremerense* populations;
- A limit on groundwater abstraction volumes;
- The development and implementation of a Mine and Infrastructure Plan to demonstrate that the final locations of mine pits and infrastructure are sited such that the disturbance of significant flora and vegetation is minimised as far as practicable;
- The implementation of a Dust Control Management Strategy to ensure that dust impacts on flora and vegetation is minimised as far as practicable; and
- The implementation of a Significant Flora Monitoring Programme to ensure that indirect impacts on flora and vegetation are strictly monitored and to allow contingency actions to be taken.

Based on the above, and the assessment provided in Sections 6 – 9, the Proposal is expected to be able to meet the EPA's objectives for Terrestrial Fauna, Subterranean Fauna, Terrestrial Environmental Quality and Inland Waters.

Residual impacts to three significant flora species (*M. aquilonaris*, *Eucalyptus rhomboidea* and *Stenanthemum bremerense*), the proposed Bremer Range Nature Reserve and the Bremer Range Vegetation Complexes PEC are considered to remain significant once mitigation measures are implemented. Offset measures are deemed to be required to counterbalance these residual impacts to ensure that the EPA objective for Flora and Vegetation can be met. Audalia has completed a WA Offsets Template as per the requirements of the WA Environmental Offsets Guideline (Government of WA, 2014), provided in Section 11. These offset measures will be reviewed and refined during the assessment process through discussions with DBCA and EPA Services to ensure they adequately counterbalance the residual impacts.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

Appendix 4: Mine Closure Plan

Appendix 5: Fauna reports

- 5.1 Fauna survey. Medcalf Vanadium Mining Project (Harewood, 2020a)
- 5.2 Short-range Endemic Fauna Report (Bennelongia, 2020a)
- 5.3 Fauna Assessment. Medcalf Vanadium Mining Project. Proposed Haul Road (Harewood, 2020b)
- 5.4 Insect visitors to *Marianthus aquilonaris* and surrounding flora (Prendergast, 2019)

Appendix 6: Assessment of Subterranean Fauna Values (Bennelongia, 2020b)

Appendix 7: Terrestrial Environmental Quality reports

- 7.1 Geochemical Characterisation of Slurry Samples of Deslimed-Tailings and Gravity-Reject-Tailings and Implications for Tailings Management (GCA, 2020a)
- 7.2 Characterisation of Mine-Waste Samples from Vesuvius, Fuji and Egmont Pits – Implications for Mine-Waste Management (GCA, 2020b)
- 7.3 Brief description of Medcalf geology Memo (Butler, 2020a)
- 7.4 Technical Memorandum: Response to EPA on Waste Rock Sampling (Butler, 2020b)
- 7.5 Tailings Storage Facility Design Concept (Golder, 2020)
- 7.6 Tailings Storage Facility Closure Design Report (Mine Earth, 2020)

Appendix 8: Hydrology reports

- 8.1 Medcalf Hydrogeological and Hydrological Study Surface Water Assessment (GRM, 2020)
- 8.2 Groundwater Supply Investigation Audalia Resources Limited Medcalf Vanadium Project (GRM, 2020)
- 8.3 Medcalf Hydrogeological and Hydrological Study Characterisation of *Marianthus aquilonaris* Habitat (GRM, 2020)
- 8.4 Medcalf Vanadium Project – Haul Road Water Supply. Technical Memorandum (GRM, 2020)

Appendix 9: GHG Estimation (Just Design Engineering, 2019)

Appendix 10: Dust Control Management Strategy (Ramboll, 2020c)

Appendix 11: Shape files of Development Envelopes and Indicative Disturbance Footprint

Appendix 12: Offset Strategy

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this Environmental Review Document (ERD) is to provide a detailed description of the Medcalf Project (Proposal) and to enable assessment of the potential environmental impacts that may result, should the Proposal be implemented. This ERD also outlines the key elements (characteristics) required for the construction and operation of the Proposal. The assessment will be completed by the Department of Water and Environmental Regulation (DWER) under the provisions of Part IV of the *Environmental Protection Act 1986* (EP Act).

This ERD has been prepared in accordance with the following Environmental Protection Authority (EPA) guidance material:

- *Environmental Impact Assessment Part IV divisions 1 and 2 Administrative Procedures* (EPA, 2016a);
- *Statement of Environmental Principles, Factors and Objectives* (EPA, 2020a);
- *Instructions on how to prepare an ERD* (EPA, 2020b); and
- *Instructions on how to define the key characteristics of a proposal* (EPA, 2016b).

This ERD focuses on the environmental factors that are deemed to be 'key' environmental factors (EPA, 2020b); those with the potential to be significantly impacted and could not be appropriately managed under other existing legislation. Potential impacts to these key environmental factors are described in detail and assessed using relevant studies specific to the Proposal. 'Other' environmental factors are discussed briefly, with a focus on demonstrating that they can be appropriately managed using a combination of industry-standard controls and other existing legislation. Therefore, this ERD describes the most relevant characteristics and impacts of the Proposal for environmental impact assessment (EIA) and provides all relevant biological and technical reports and survey results as Appendices.

1.2 PROPONENT

The Proponent for this ERD is Audalia Resources Limited (ABN: 49 146 035 690):

Contact Person:	Geoffrey Han – Project Director
Email:	geoffrey.han@audalia.com.au
Phone:	+61 8 9321 0715
Address:	Level 1, Office F, 1139 Hay Street, West Perth, WA, 6005
Postal Address:	PO Box 354, West Perth, WA, 6872

1.3 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

Key EIA legislative requirements relating to the Proposal are discussed in the following sections.

1.3.1 PART IV OF THE *ENVIRONMENTAL PROTECTION ACT 1986*

Part IV of the EP Act makes provisions for the EPA to undertake EIA of significant proposals, strategic proposals and land use planning schemes. The Proposal is considered to be a 'significant proposal' and as such requires assessment under Part IV of the EP Act.

The EPA uses environmental principles, factors and associated objectives as the basis for assessing whether a proposal or land use planning scheme's impact on the environment is acceptable. The environmental principles, factors and objectives, therefore, underpin the EIA process.

The Proposal was referred under Section 38 of the EP Act on 20 December 2017. The EPA released their decision to assess the Proposal as a Public Environmental Review (s. 40(2)(b) and s. 40(4)), with a public review period of eight weeks, on 19 March 2018. A proponent-prepared Environmental Scoping Document (ESD) was submitted to the EPA and approved on 1 April 2019.

1.3.2 *Environment Protection and Biodiversity Conservation Act 1999*

The Proposal was referred to the Department of Agriculture, Water and the Environment (DAWE) in November 2017 (EPBC Ref: 2017/8113). The DAWE advised on 9 January 2018 that the proposed action was not a controlled action and no further assessment and approval was required under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth; EPBC Act).

1.4 Other Approvals and Regulation

1.4.1 Land Tenure

The Proposal is to be implemented on the following tenure (Figure 12):

- Mining activities will be undertaken within M63/656, issued under the *Mining Act 1978* (Mining Act);
- The transport corridor and water supply will be developed within L63/75, a miscellaneous licence; and
- Intersection works will be undertaken within the Coolgardie-Esperance Highway road corridor managed by Main Roads WA (MRWA).

1.4.2 Other Decision-Making Authorities, Approvals and Regulation

Table 1 identifies other approvals and associated legislation that will apply to the Proposal. The relevant decision-making authorities have also been identified for each approval or legislation.

Table 1: Other approvals

Proposal Activities	Land Tenure/Access	Type of Approval	Legislation Regulating the Activity	Decision-making authority
All activities	M63/656 & L63/75, MRWA road corridor	Part IV EP Act approval	EP Act (Part IV)	Minister of Environment
All proposed activities apart from road intersection	M63/656 & L63/75	Mining Proposal (MP)	Mining Act	Minister for Mines and Petroleum
Closure of all proposed activities apart from road intersection	M63/656 & L63/75	Mine Closure Plan (MCP)	Mining Act	Minister for Mines and Petroleum

Proposal Activities	Land Tenure/Access	Type of Approval	Legislation Regulating the Activity	Decision-making authority
Exploration for groundwater sources	M63/656 & L63/75	Programme of Works (PoW)	Mining Act	Minister for Mines and Petroleum
Groundwater abstraction	M63/656 & L63/75	26D Licence	*Rights in Water and Irrigation Act 1914* (RIWI Act)	Minister for Water
		5C Licence	RIWI Act	Minister for Water
Ore processing, tailings disposal, sewage treatment and disposal, crushing and screening	M63/656 & L63/75	Works Approval and Licence	Part V EP Act	Minister for Environment
Accommodation camp	M63/656	Building Licence	*Building Act 2011*	Minister of Commerce
		Approval to construct and operate an apparatus for the treatment of sewage	*Health Act 1911*	Minister of Health
Disturbance of Aboriginal heritage sites (if they cannot be avoided)	M63/656 & L63/75	Section 18 approval	*Aboriginal Heritage Act 1972*	Minister for Aboriginal Affairs
Fuel and/or chemical storage (if above prescribed volumes)	M63/656 & L63/75	Dangerous Goods Licence	*Dangerous Goods Safety Act 2004*	Minister for Mines and Petroleum
Safety Management	Mining Act tenure	Project Management Plan	*Mines Safety and Inspection Act 1994* (WA)	Minister for Mines and Petroleum
Transport of heavy equipment on public roads	Road reserves	Heavy Haulage Approval	*Main Roads Act 1930*	Minister for Transport
Coolgardie-Esperance Highway intersection works	Road reserves	Agreement	*Main Roads Act 1930*	Minister for Transport

2 THE PROPOSAL

2.1 BACKGROUND

The Proposal was referred under Section 38 of the EP Act on 20 December 2017. The EPA released their decision to assess the Proposal as a Public Environmental Review (s. 40(2)(b) and s. 40(4)), with a public review period of eight weeks, on 19 March 2018. A proponent-prepared ESD was submitted to the EPA and approved on 1 April 2019.

2.2 PROPOSAL DESCRIPTION

2.2.1 PROPOSAL LOCATION

The Proposal is to develop the Medcalf Project which is located in the Bremer Range, Lake Johnston region of WA, approximately 470 km east south-east of Perth (Figure 1).

Figure 1: Regional location of the Proposal

2.2.2 Key Proposal Characteristics

Audalia has referred to the EPA's *Instructions on how to define the key characteristics of a proposal* (EPA, 2016b) - which focuses on proposals for the purposes of EIA under Part IV of the EP Act. In accordance with these instructions, a summary of the Proposal is provided in Table 2 and the key proposal elements (e.g. development, action, activities or processes) which are likely to cause an impact on the environment are summarised in Table 3.

Table 2: Key Characteristics of the Proposal

Proposal Title	Medcalf Project
Proponent Name	Audalia Resources Limited
Short Description	The Proposal is to develop a vanadium, titanium and iron mining operation, approximately 100 km southwest of Norseman, WA. The Proposal includes the development of three or four open mine pits, beneficiation plant, tailings storage facility (TSF), private haul road, road train transfer area and associated infrastructure such as laydown areas, borrow and gravel pits, groundwater bores, workshops and accommodation camp.

Table 3: Indicative location and proposed extent of physical and operational elements

Element	Indicative Location	Proposed Extent
Physical Elements		
Mine and associated infrastructure	Figure 2 and Figure 3	Clearing of no more than 300 ha within the 898 ha Mine Development Envelope (DE)
Haul Road and associated infrastructure	Figure 2, Figure 4 and Figure 5	Clearing of no more than 350 ha within the 1,633 ha Haul Road DE
Significant flora	Figure 57 and Figure 66	Clearing of no more than: • 1.51 ha of *M. aquilonaris* sub-optimal habitat • 0.4 ha of *Eucalyptus rhomboidea* population extent • 21 ha of *Stenanthemum bremerense* population extent
Operational Elements		
Tailings disposal	Figure 3	Disposal of no more than 7.2 Million tonnes of tailings into the TSF
Groundwater supply borefield	Figure 3	Abstraction of no more than 1.2 GL per annum, of which no more than 0.8 GL per annum is to be abstracted from the mine site borefield

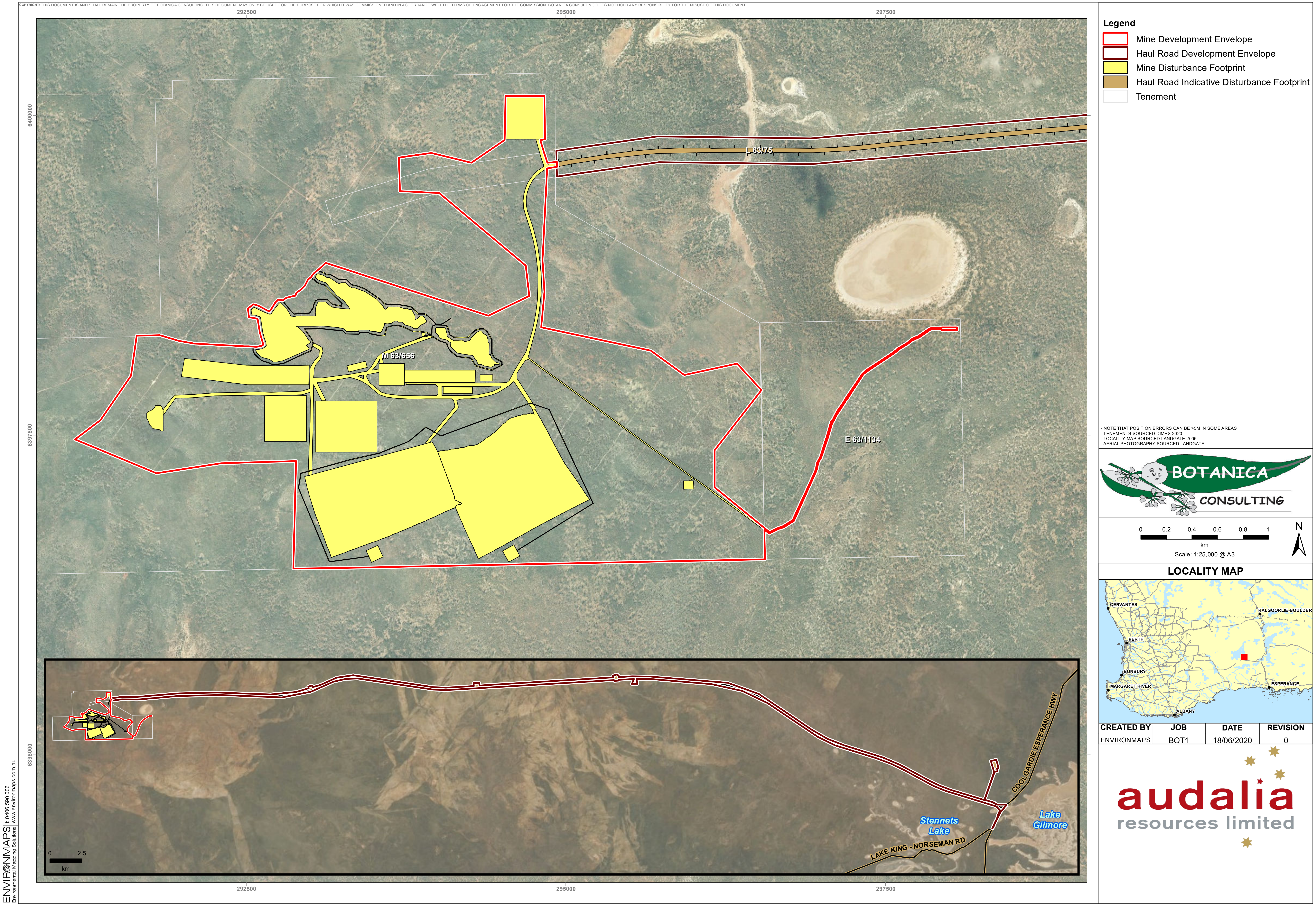


Figure 2: Development Envelopes

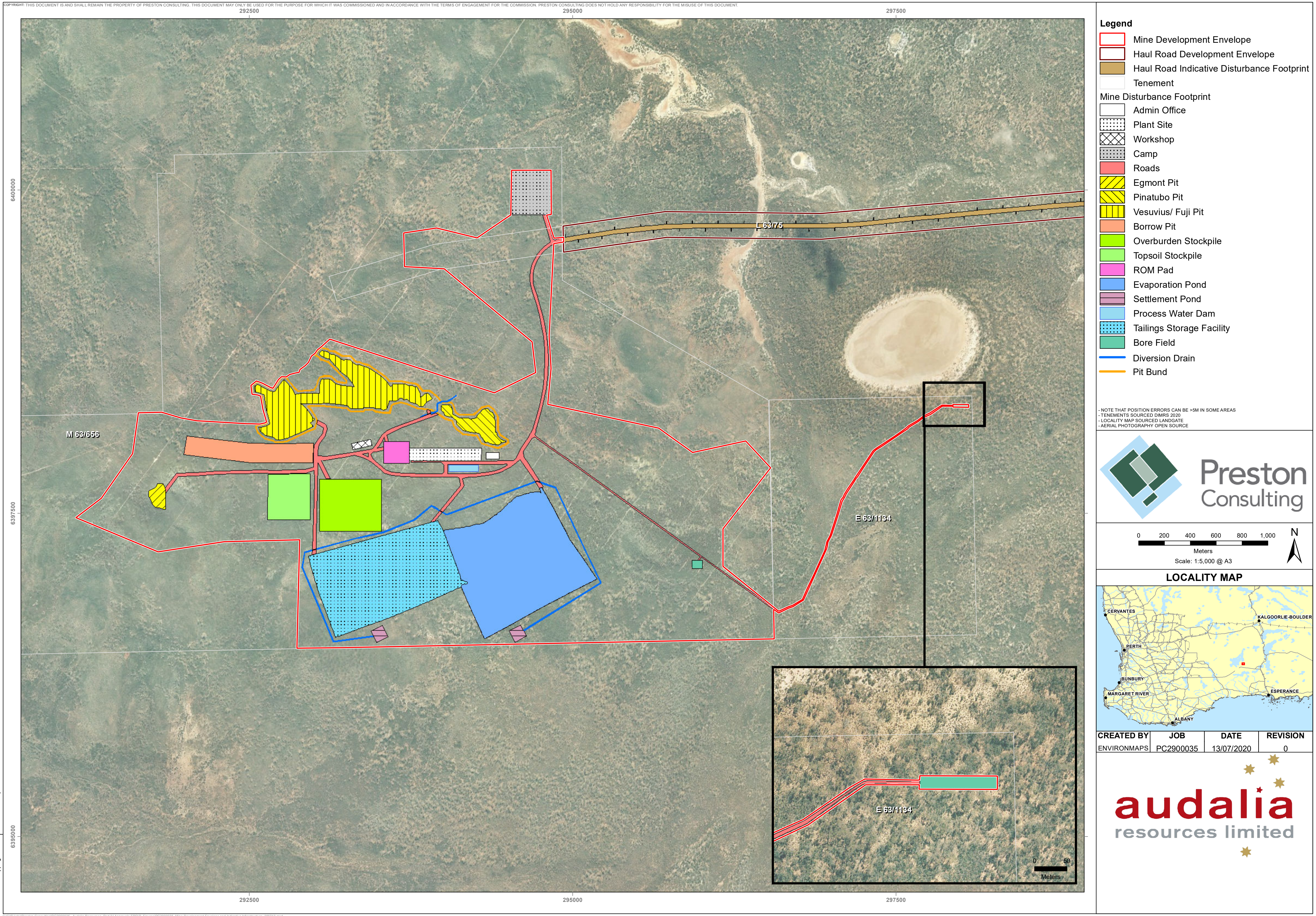


Figure 3: Mine DE and indicative infrastructure

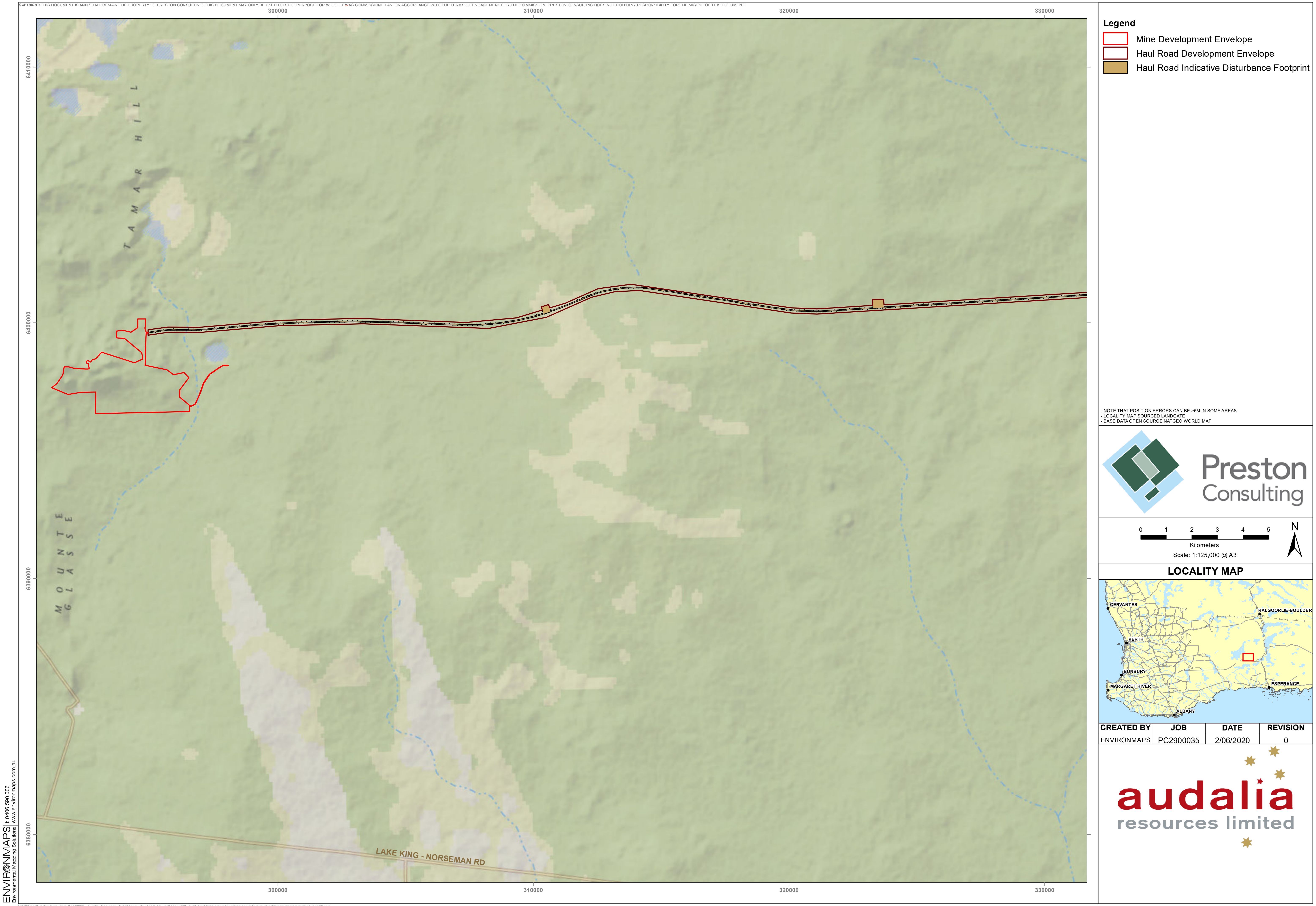


Figure 4: Haul Road DE and indicative layout (1 of 2)

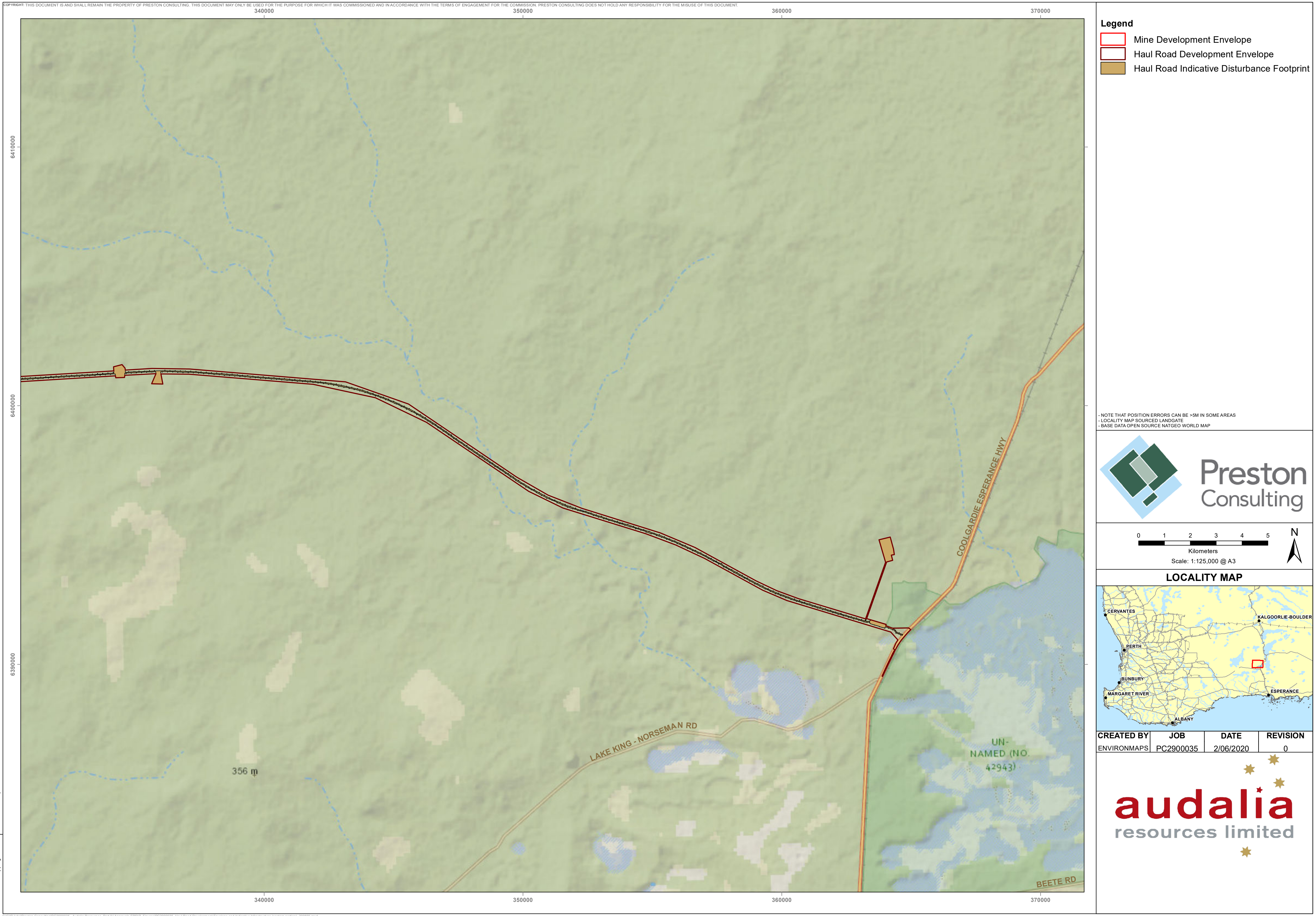


Figure 5: Haul Road DE and indicative layout (2 of 2)

2.2.3 Detailed Description

Overview

The Proposal is a vanadium, titanium and iron deposit with a JORC (2012) compliant Indicated and Inferred Mineral Resource totalling 32 million tonnes (Mt) at 0.47% V_2O_5, 8.98% TiO_2 and 49.2% Fe_2O_3.

The Proposal involves mining, processing and exporting a concentrate of vanadium, titanium and iron. The Proposal includes the development of three or four open mine pits, beneficiation plant, TSF, evaporation ponds, mine closure materials area, topsoil stockpile, private haul road, road train transfer area and associated infrastructure such as laydown areas, borrow and gravel pits, groundwater bores, workshops and an accommodation camp.

Audalia intends to transport the concentrate product in road trains from the mine to a transfer hub at the Coolgardie to Esperance Highway via a 74 km private haul road. The concentrate will then be loaded onto smaller road trains (to meet highway restrictions) and transported to the Port of Esperance for export.

The Proposal consists of two distinct DEs; a Mine DE and a Haul Road DE. These DEs are located within a Mining Lease M63/656 and a Miscellaneous Licence L63/75 respectively (Figure 2).

The Mine DE will require clearing of no more than 300 ha within the 898 ha of the total mine DE in order to develop the mine pits and associated infrastructure (Figure 3). The Haul Road DE will require clearing of no more than 350 ha within the 1,633 ha of the total Haul Road DE in order to develop the haul road and associated infrastructure (Figure 4 and Figure 5).

Mining

Open pit mining is planned to be undertaken to shallow depths of approximately 50 m from three or four separate open pits; namely Vesuvius, Fuji, Egmont and Pinatubo (Figure 3). All open pits are above groundwater table. Cube Consulting Pty Ltd (Cube) has undertaken a range of open pit optimisation studies and selected the most economic pit shell for each prospect. The mining study (Cube, 2019) identified a combined ore tonnage inventory of 19.1 Mt with a very low total strip ratio (waste : ore tonnes) of only 0.15 to 1. A mining production schedule was completed using the final and staged pit designs with a minimum annual ore production of 1.5 million tonnes per annum (Mtpa) and a life of mine of 13 years. The resultant estimates of ore and waste being extracted from each mine pit are shown in Knight Piesold Pty Ltd (Knight Piesold) conducted a geotechnical desktop study of the proposed pit slope profiles and assessed stability. Knight Piesold (2019) recommended a safety bund of at least 17 m away from the crest of the pit slopes as shown in Figure 6. This recommendation will be incorporated in the final mine design to prevent surface run-off from flowing into the pit and eroding the pit slope surfaces.

Table 4.

These resulted in a total of 19.1 Mt of Ore at 53.36% average hematite (Fe_2O_3) grade, 0.51% average vanadium pentoxide (V_2O_5) grade, 9.34% average titanium dioxide (TiO_2) grade; and 2.8 Mt of waste resulting in a waste: ore strip ratio of 0.15

The current pit shell footprints and tonnages are listed in Knight Piesold Pty Ltd (Knight Piesold) conducted a geotechnical desktop study of the proposed pit slope profiles and assessed stability.

Knight Piesold (2019) recommended a safety bund of at least 17 m away from the crest of the pit slopes as shown in Figure 6. This recommendation will be incorporated in the final mine design to prevent surface run-off from flowing into the pit and eroding the pit slope surfaces.

Table 4 and are shown in Figure 3.

Knight Piesold Pty Ltd (Knight Piesold) conducted a geotechnical desktop study of the proposed pit slope profiles and assessed stability. Knight Piesold (2019) recommended a safety bund of at least 17 m away from the crest of the pit slopes as shown in Figure 6. This recommendation will be incorporated in the final mine design to prevent surface run-off from flowing into the pit and eroding the pit slope surfaces.

Table 4: Mine pits footprint and tonnages

Mine Pit	Pit shell footprint (ha)	Ore tonnages (Mt)	Waste tonnages (Mt)
Egmont	1.96 ha	0.82	0.10
Vesuvius/Fuji	31.51 ha	16.73	2.44
Pinatubo	5.85 ha	1.55	0.26
TOTAL	39.32 ha	19.1	2.8

Waste Rock Disposal

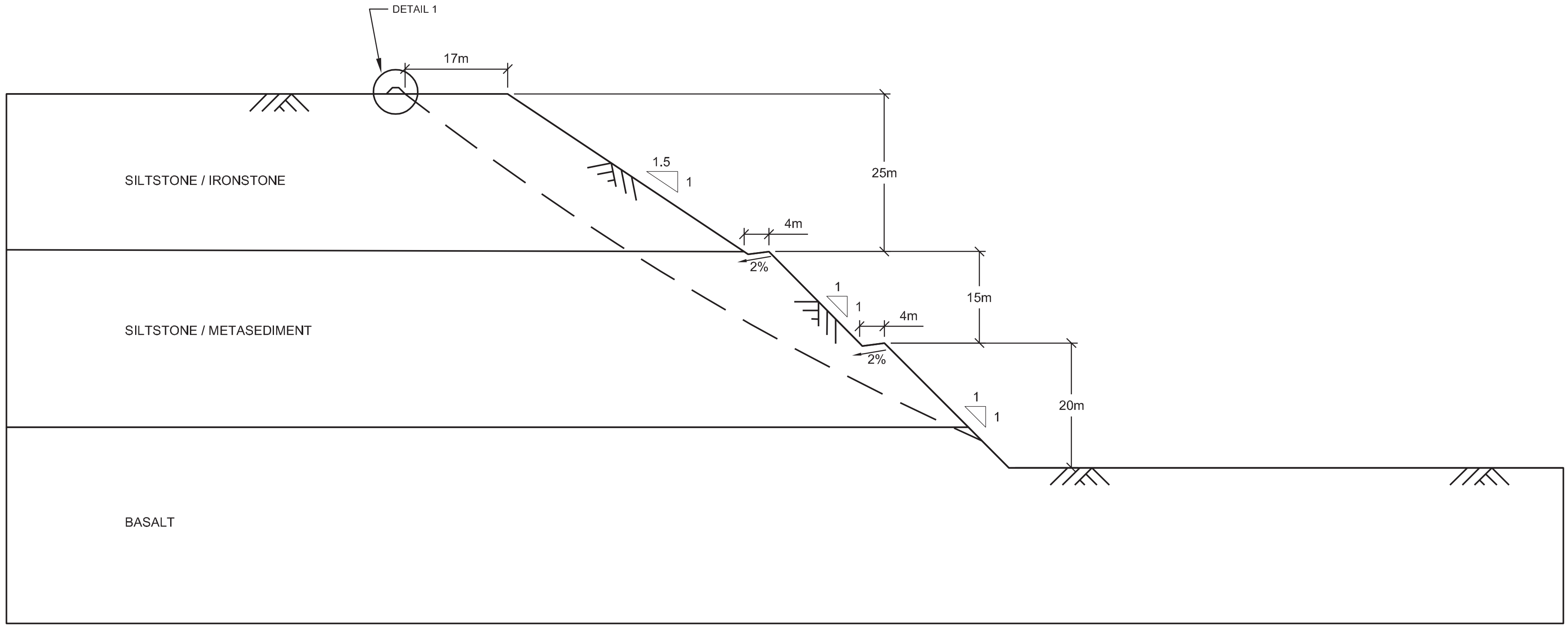
The majority of waste rock will be used for mine closure. An estimated of 1.6 Mm^3 will need to be used to construct the TSF. Waste rock will be disposed into the void created by the excavation of construction material for the TSF. This has allowed Audalia to remove the requirement for a waste rock landform (WRL). A temporary waste rock stockpile (known in the mine design layout as a mine materials closure area) will be developed next to the void to allow waste material to be stored while the TSF is being constructed.

Processing

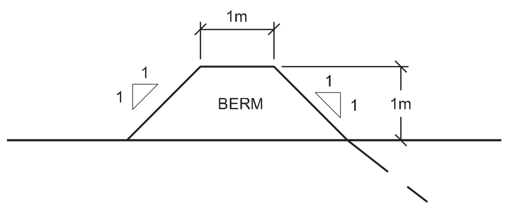
The processing plant incorporates a comminution circuit and a magnetic beneficiation circuit. The comminution circuit includes crushing and milling processes; and the magnetic separation circuit consists of two different types of magnetic separation plants.

The processing plant will upgrade the run of mine (ROM) ore to the primary concentrate by removing the gangue materials through the beneficiation circuit. The primary concentrate will then be dewatered by thickening and filtration, with the filter cake stacked and prepared for transport (Figure 7).

The tailings generated from the magnetic separation circuit will be thickened and stored in a TSF (refer section below).



TYPICAL OPEN PIT SECTION



DETAIL 1

MEDCALF PROJECT
DESKTOP STUDY OF NORTH SHELL SLOPE STABILITY
PROPOSED NOTH OPEN PIT SHELL SLOPE PROFILE

Figure 6: Proposed slope and bund profiles

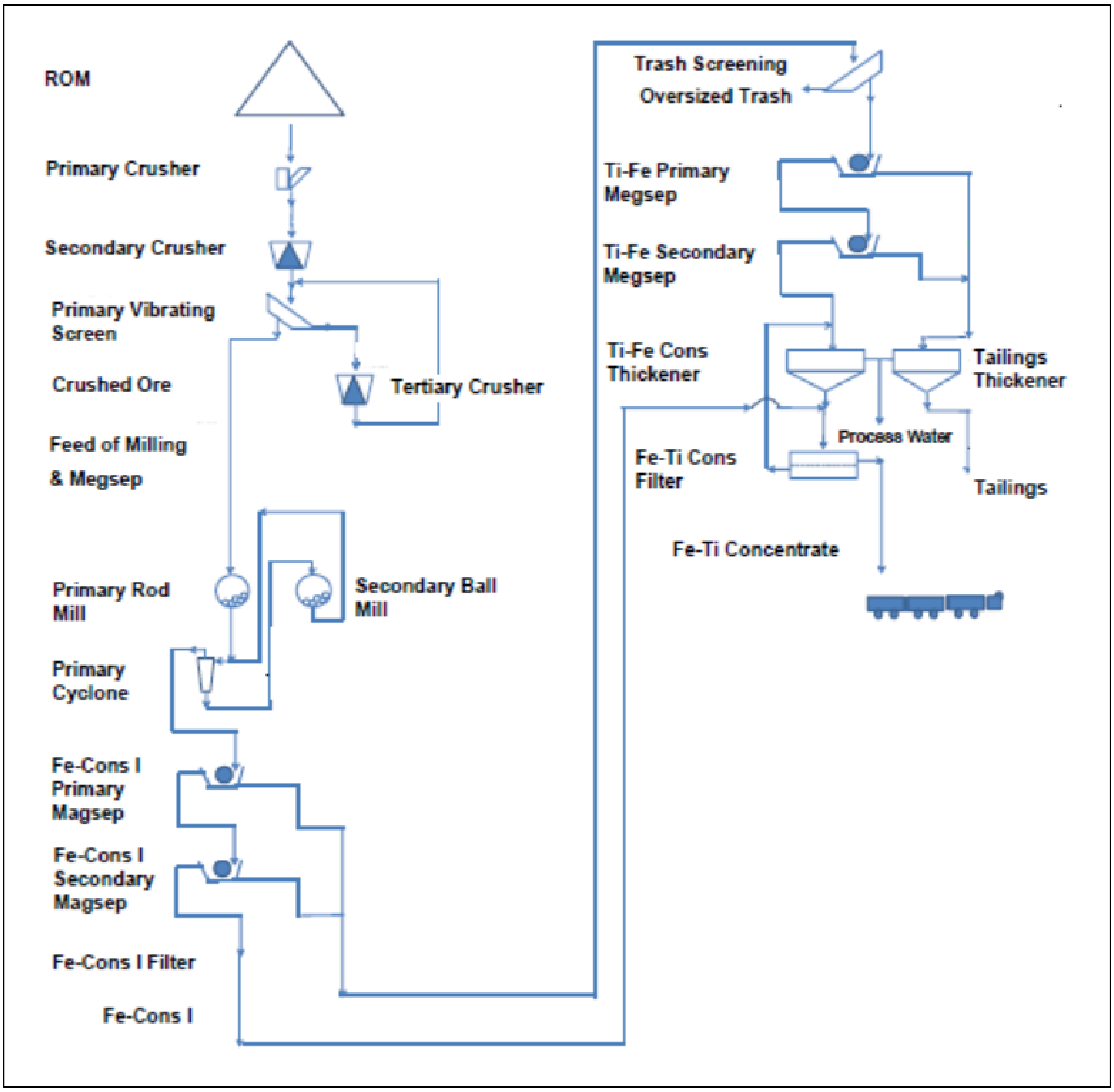


Figure 7: Process flow diagram

Tailings Disposal

Golder Associates Pty Ltd (Golder) was commissioned to provide a conceptual design of the TSF (Appendix 7.5). Based on the current mining rate of 1.5 Mtpa, there will be a requirement to store approximately 7.2 million tonnes (Mt) of tailings / process waste production over the 13 year mine life (Golder, 2020).

A side-hill TSF design was selected to be constructed with locally borrowed material to provide a sufficient capacity to retain tailings for the anticipated 13 years of production. The TSF will be located to the south of mining operations within Audalia's Mining Lease (M63/656) (Figure 8).

Audalia has opted to select the slurry tailings option, which will form the basis of the design concept. However, Audalia is investigating filtered tailings options to increase reuse of available water and reduce the water demands across the site.

The TSF downstream batter slopes of confining embankment are planned to be constructed at a slope of 1V:3H, about 18°. This relatively flat batter will allow the slopes to be trafficked during closure. The upstream batter slopes have been assumed to be constructed at a slope of 1V:2H, about 27°.

Tailings will be deposited as a slurry at a beach slope of 0.5% allowing for a 300 mm freeboard. Deposition will occur from the confining embankments resulting in the supernatant pond being located in the north of the facility, providing sufficient freeboard to contain a 1 in 100 year, 72-hour rainfall event. The supernatant pond will be remote from the embankment reducing risks associated with embankment instability, overtopping and seepage. Water will be collected from the TSF by either a pump located on a floating barge or turret decant system for reuse within the processing circuit (Golder, 2020).

The concept assumes that the embankment would be constructed using the downstream raise approach or constructed as a single embankment prior to commencement of operations, depending on availability of materials locally and waste scheduling from the pit(s).

The TSF will have a crest of 10 m to allow for the implementation of the tailings delivery pipeline, safety windrow and vehicle access tracks. TSF cross-sections are presented in Figure 9. The volume of fill required to construct the TSF is estimated to be approximately 1.6 Mm^3.

The rate of rise of the hydraulically-deposited tailings will be approximately 2 m per year. This rate of rise is aimed at achieving air dying of the tailings away from the supernatant pond and the targeted overall average tailings dry density of 1.5 t/m^3 for the tailings. In the areas of the TSF where tailings are submerged by water, the tailings will only consolidate through self-weight and thus likely reach a lower density than on the beaches.

The TSF is expected to undergo a total of 3 - 4 m of consolidation settlement, based on the consolidation test results obtained by Golder. The majority of this consolidation settlement is expected to occur during operation of the TSF due to the low rate of rise. Therefore, only a small amount of post operational settlement is expected.

Evaporation Ponds

Two evaporation ponds (Figure 8) have been designed to provide storage of approximately 500,000 m^3 per annum. The evaporation ponds are required to store the brine water generated from the reverse osmosis plant (RO plant). The process plant requires 805 kL/day of fresh water, which will be obtained from the RO plant through treatment of groundwater. Considering a 40% conversion rate, a total of approximately 1,200 kL/day will be discharged into the evaporation pond.

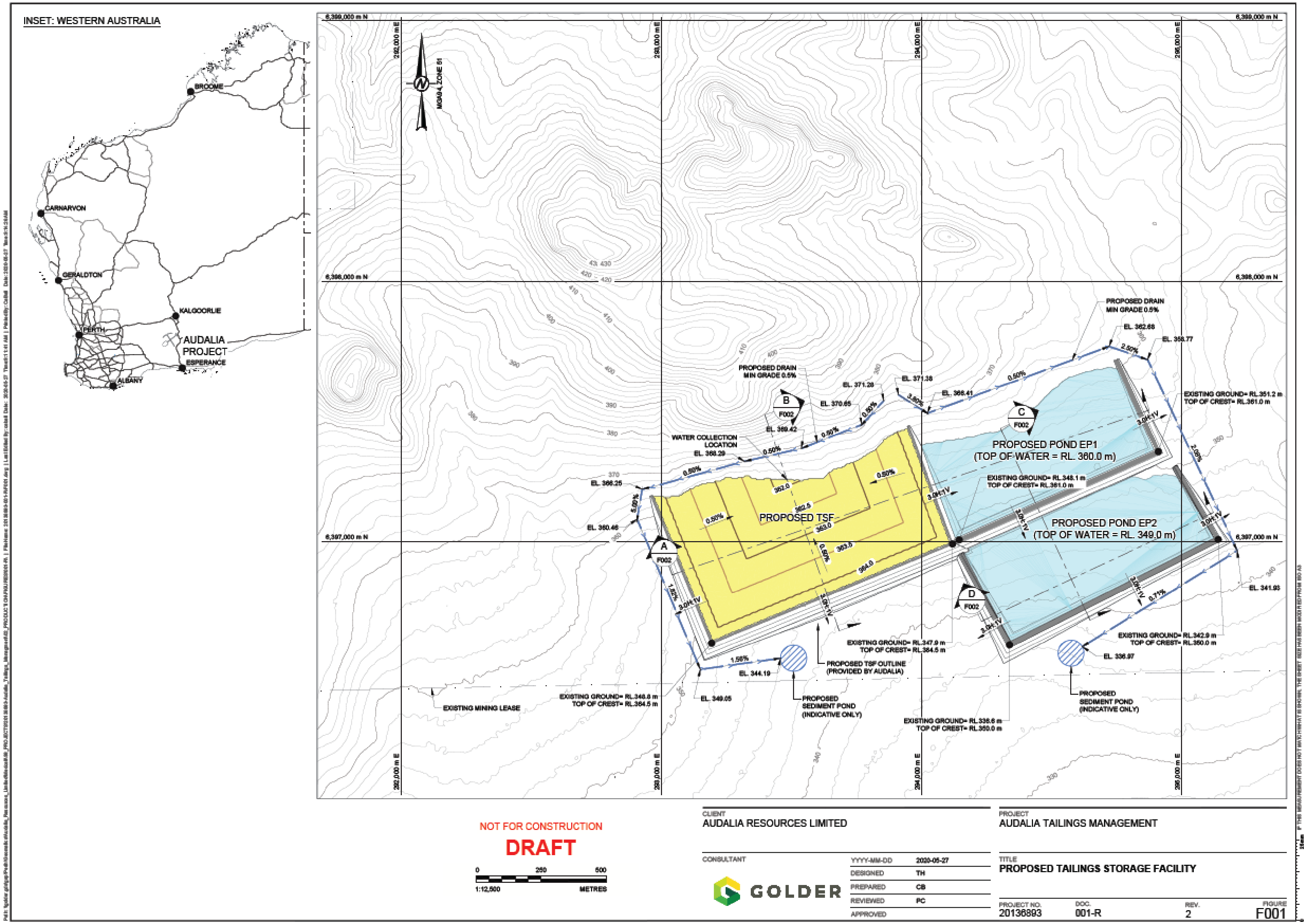


Figure 8: Layout of the TSF and Evaporation Ponds

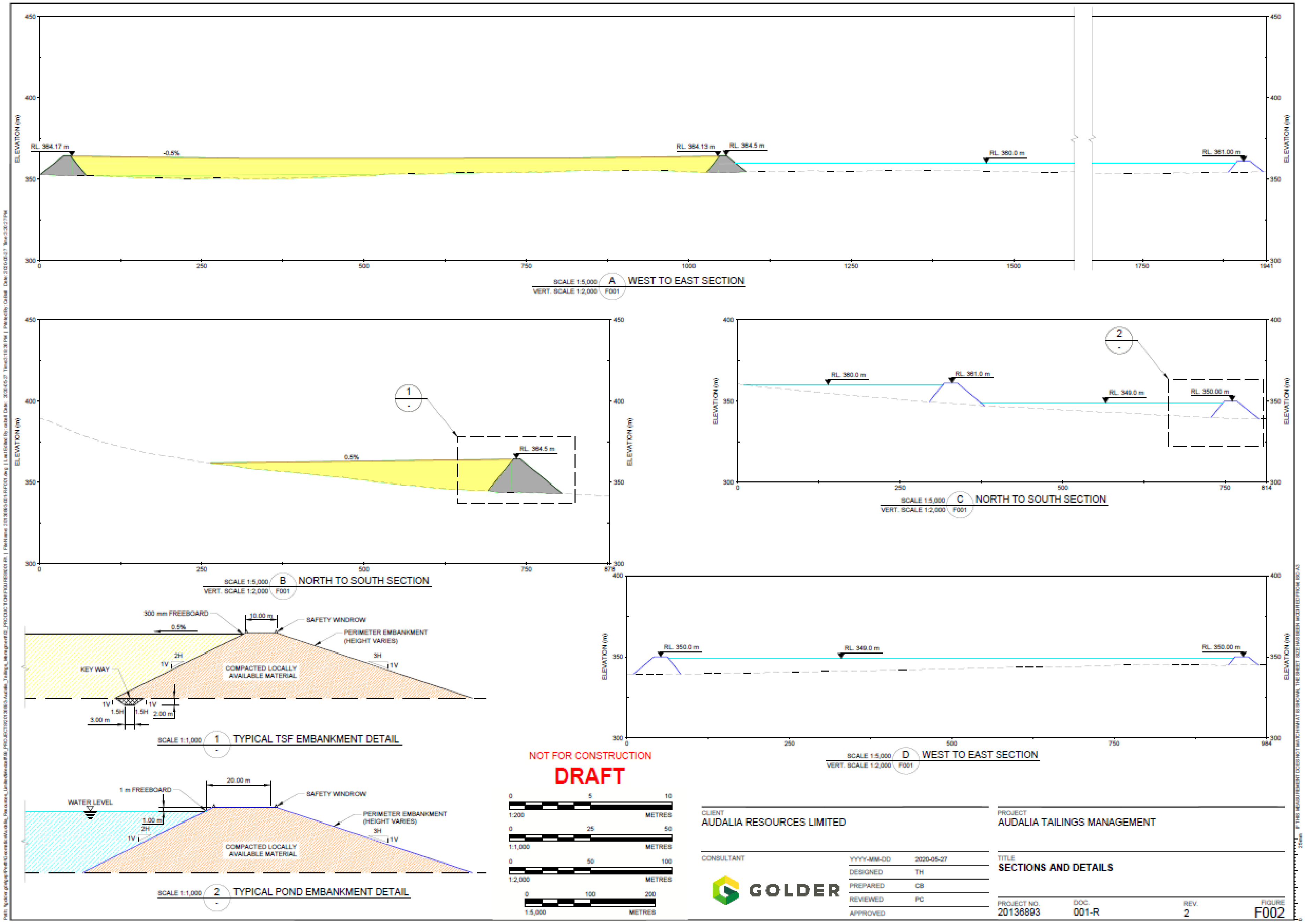


Figure 9: TSF cross-sections

Haul Road

As there are no major roads within the proposed mine area, a 74 km unsealed private haul road is proposed from the mine site to an ore transfer hub adjacent to the Coolgardie-Esperance Highway (Figure 4 and Figure 5). Audalia investigated numerous access and haulage options for the Proposal and determined that a private haul road was the most appropriate method of safely enabling concentrate to be transported from the mine site. A detailed description of the options analysis conducted for the haul road is provided in Section 2.2.3.

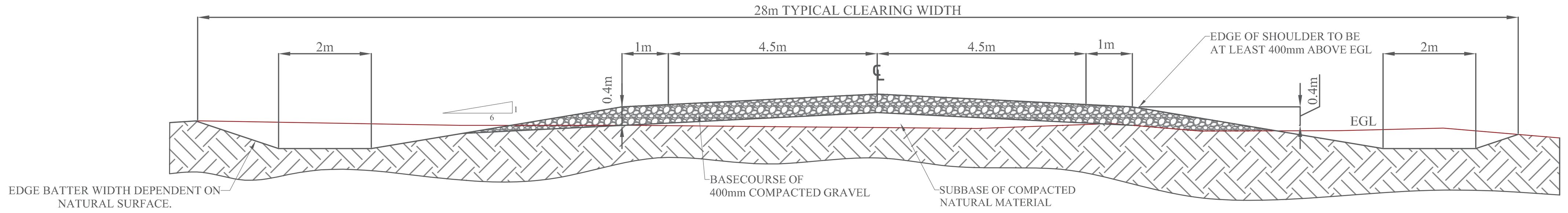
The road will have a running surface of approximately 11 m width and requires an average disturbance width of approximately 40 m (Figure 10). This average disturbance width allows for wider areas where drainage features are installed. The haul road will follow the path of existing tracks along most of its length (where suitable) to minimise vegetation disturbance.

The primary concentrate is to be hauled by heavy haulage road trains along this haul road. The availability of a private haul road means that larger haul trucks can be used that allows the ore to be transported more efficiently and with less emissions.

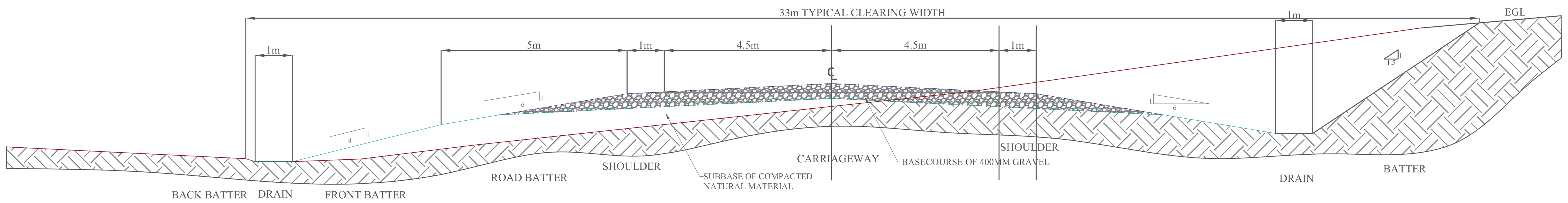
Export

Approximately 17 road trains per day will transport the concentrate via the private haul road from mine to the transfer hub adjacent to the Coolgardie - Esperance Highway. When the heavy haulage road trains reach the transfer hub the concentrate will be either transferred to a smaller road train or will continue south to the Esperance Port as highway-approved road trains by disconnecting the required number of trailers in order to comply with the highway restrictions. There is a widening of the DE near the Coolgardie - Esperance Highway to accommodate the transfer area.

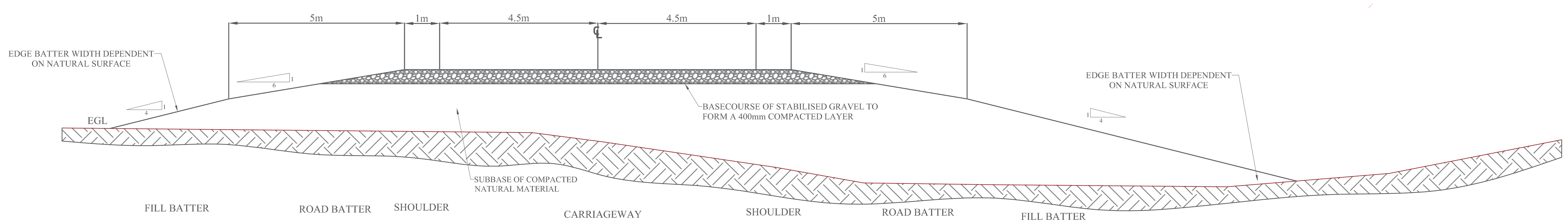
Approximately 34 road trains per day will transport the concentrate to Esperance Port via the Coolgardie – Esperance Highway. Only minor works are required to be undertaken at Esperance Port to accommodate the new shipment (conducted by a third party - outside the scope of this ERD). The concentrate is planned to be stored within the enclosed storage shed before being loading to the shipping vessel via an existing export berth and shiploader. These works and activities do not form part of this Proposal as they are managed under approval from the Southern Ports Authority.



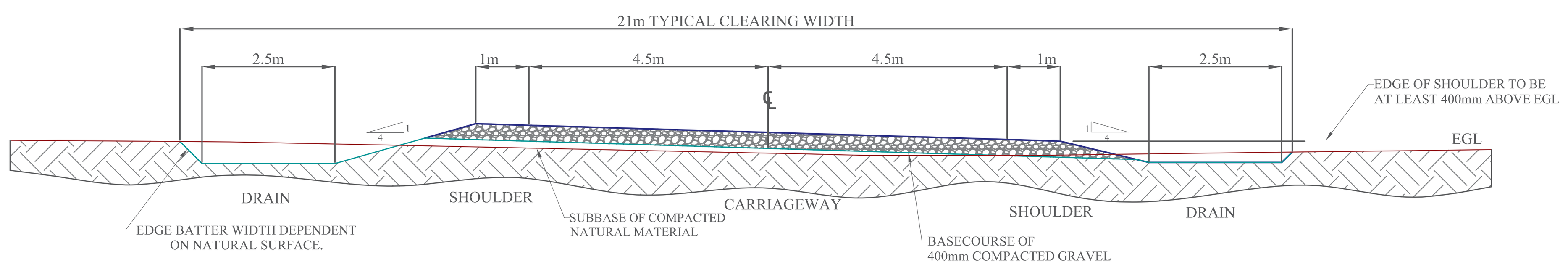
CROSS SECTION - CROWNED WITH CHANNEL SIDE DRAINS



CROSS SECTION - CROWN PROFILE WITH SIDE DRAINS



CROSS SECTION - FILL ON CREEK CROSSING



CROSS SECTION - SUPERELEVATED WITH CHANNEL SIDE DRAINS

No	DATE	DRAFTING CHECK	DESIGN REVIEW	APP'D DES	APP'D Atlas	REVISION

ROADMILES
Consulting Civil & Traffic Engineers
P: 0417 433 657
E: admin@roadmiles.com.au

SIGNED APPROVAL			
LEAD DISCP. ENG:	G. Miles	DATE:	
PROJ. MGR:	G. Miles	DATE:	
PROJ. DIR:	G. Miles	DATE:	

DOCUMENT No.

audalia resources limited

CLIENT SIGNED APPROVAL		
Project Manager		
Project Engineer		

TITLE
MEDCALF LONG HAUL ROAD
TYPICAL CROSS SECTIONS

SCALE	PROJECT DOCUMENT No	SHEET	REV
		1 OF 1	A

A1

Figure 10 : Typical Road Cross Section

Supporting Infrastructure

The Proposal requires water for mine processing, dust suppression, accommodation and workshop facilities. This will be pumped via surface pipelines from a series of new bores targeting sources just east of the mining area, and along the haul road (Figure 3 to Figure 5). The water supply is brackish to saline, which is suitable for processing and dust suppression (with specific controls), however a small reverse-osmosis plant will be installed to supply fresh water for concentrate washing and potable water for personnel.

Power will be supplied initially by a series of diesel-fuelled generators with local power lines for electrical distribution. Solar panels may be used in conjunction with diesel generators to provide power where appropriate.

Accommodation for up to 80 people is required to operate and maintain the site operations, with up to 150 additional construction rooms if required. The accommodation village will be located within the Mine DE (Figure 3).

Other supporting infrastructure may include workshops, laydown, landfill, fuel storage and communications.

2.2.4 DISTURBANCE AND DEVELOPMENT ENVELOPES

The proposed DEs outline the boundaries for the Proposal (Figure 2), where all ground disturbance and indicative key proposal elements listed below are proposed to occur. A total disturbance limit of 650 ha is proposed, within a total development envelope of 2,531 ha. Two separate development envelopes are proposed, as the type of disturbance varies between activity types.

The Mine DE is located within Audalia's mining lease M63/656 and covers an area of 898 ha. Up to 300 ha of vegetation disturbance will be required within the 898 ha Mine DE in order to develop the following:

- Three or four surface open mine pits, over an area of approximately 40 ha;
- Ore beneficiation plant;
- Borrow pit;
- ROM pad;
- TSF;
- Evaporation ponds;
- Process water dam;
- Topsoil stockpile area;
- Temporary mine closure materials area (overburden stockpile);
- A groundwater borefield that will supply water to the mine, accommodation and transport infrastructure; and
- Associated onsite supporting infrastructure including accommodation village, water supply, laydown areas, workshops and administration offices.

The Haul Road DE covers an area of 1,633 ha. A total of 350 ha of vegetation disturbance will be required within the Haul Road DE in order to develop the following:

- A private haul road approximately 74 km in length running east from the mine site to the Coolgardie-Esperance Highway;

- Associated borrow and gravel pits;
- Drainage;
- A road train transfer area located close to the Coolgardie-Esperance Highway;
- Acceleration and turning lanes on the Coolgardie-Esperance Highway; and
- Associated infrastructure including laydown areas, offices and workshops.

The shape files of the DEs have been provided in Appendix 11.

2.2.5 Changes to the Proposal

A number of key Proposal elements have changed since it was originally referred to the EPA under Section 38 of the EP Act. The changes to the Proposal are described in Table 5. Pursuant to section 43A of the EP Act, the EPA consents to the Proponent making the following changes to the Proposal.

Table 5: Changes to the Proposal since referral

Proposal element	Original referral	Current proposal	Rationale for the changes
Mine DE boundary	Disturbance of no more than 300 ha within the 1,736 ha Mine DE	Disturbance of no more than 300 ha within the 898 ha Mine DE	Project design updates to avoid all direct impacts to Threatened Flora *Marianthus aquilonaris* populations and reduce direct impacts to Priority Flora, as well as minimise indirect impacts. The revised Mine DE also includes an existing track to the mine borefield (i.e. no clearing proposed in this area).
Significant flora disturbance	No reference	Clearing of no more than: • 1.51 ha of *M. aquilonaris* sub-optimal habitat • 0.4 ha of *Eucalyptus rhomboidea* population extent • 21 ha of *Stenanthemum bremerense* population extent	Project design updates and detailed survey information have allowed accurate limits to be set to restrict direct impacts to Priority Flora.
WRL	Proposal included a WRL	WRL is no longer part of the Proposal	Waste rock will now be used for construction material with any excess placed as backfill within a void created by sourcing construction material for the TSF.
Evaporation ponds	No reference	Evaporation ponds are included in Proposal description	Evaporation ponds were deemed to be required to hold the brine from the RO Plant. This was an outcome of detailed groundwater investigations which determined that the available water supply was saline and RO was required to provide fresh water for processing and potable uses.
Groundwater abstraction	Abstraction of no more than 0.8 GL per annum	Abstraction of no more than 1.2 GL per annum	Detailed groundwater investigations have identified that groundwater quality is saline and treatment by a Reverse Osmosis (RO) Plant will be required to provide fresher water for processing. As such additional groundwater will need to be abstracted to account for the amount lost as brine from the RO Plant.

2.3 JUSTIFICATION

2.3.1 DO NOTHING APPROACH TO THE PROPOSAL

Audalia has conducted a review of the current iron, vanadium and titanium markets, utilising leading industry market research reports and market enquiries. It was identified that these markets both have a positive long-term outlook. Strong global demand for iron ore is driven by the steel industry through urbanisation taken place in China and other Asian countries for the construction of infrastructures. Vanadium is currently mined in a few countries, i.e. China, Russia, South Africa and Brazil. Over 90% of vanadium product is used in the steel industry as strengthening agent. Demand in new markets such as super alloys and flow batteries known as the Vanadium Redox Battery (VRB) has resulted in a supply gap forecast to a price rise. The rechargeable batteries can be used for large scale applications including back-up storage for electrical power grids. Titanium dioxide is the most used white pigment globally and about 60% of the titanium dioxide is used in coatings market (paints, coatings, inks and enamels). It is forecast that China and other Asia-Pacific Country markets are the main growth regions due to the strong consumer demand.

The Proposal has been and will be subject to thorough feasibility studies to ensure that financial aspects are considered and potential profits justify the capital and operational expenditure. Initial financial analysis has indicated that the capital expenditure will be paid back within three years once operational.

Based on this outlook, Audalia predicts a strong demand for its vanadium and titanium products. The 'do nothing' approach to the Proposal represents a lost commercial opportunity to Audalia.

2.3.2 OTHER TECHNOLOGIES OR OPTIONS

Audalia is planning to process the ore at the mine site to produce a concentrate product. Audalia had investigated the option of developing a hydrometallurgical processing plant and a sulphuric acid plant either at the mine site or adjacent to the Coolgardie-Esperance Highway. This option was however not pursued due to the high capital cost, as well as handling of dangerous goods and special requirement for plant operators.

The further treatment of the concentrate overseas means that the environmental impacts associated with downstream processing such as air emissions, waste and vegetation clearing are avoided in WA.

2.3.3 ALTERNATIVE LOCATIONS AND DESIGNS CONSIDERED

Mine Site

The Proposal has been optimised to minimise environmental impacts as much as practicable. Audalia developed the boundaries of the two DEs by excluding the following environmental features to minimise the potential environmental impacts:

- All known current records of *Marianthus aquilonaris* (*M. aquilonaris*) (Threatened Flora under the *Biodiversity Conservation Act 2016* (BC Act);
- Nature Reserve R42943 (adjacent to Coolgardie – Esperance Highway);
- Surface water features (such as salt lakes) where practicable; and

- Recorded Priority Flora locations where practicable.

The following design alterations were also implemented to minimise environmental impacts:

- The Vesuvius mine pit was significantly reduced to avoid direct impacts to current sub-populations of *M. aquilonaris;*
- The proposed WRL was removed from the Proposal which allowed recorded Priority Flora to be avoided; and
- Infrastructure within the Mine DE has been moved to avoid recorded Priority Flora species wherever practicable.

Haul Road

The Proposal includes the transportation of ore to the Port of Esperance for export to overseas markets. Audalia has engaged stakeholders and road engineers to perform an options assessment analysis to consider various transportation options, including a slurry pipeline and construction of a new haul road. A slurry pipeline and nine haul road transport options were analysed for environmental, safety, heritage, Native Title and other social considerations. These options are discussed below.

<u>Slurry Pipeline</u>

Audalia considered the construction of a slurry pipeline to transport product to the port. The pipeline would also require an access road alongside the pipeline. This option was discounted due to the significant capital cost and the risk of leakages.

<u>Haul Road Options</u>

A triple trailer heavy duty road train is proposed as the most efficient haulage configuration. The requirements for heavy haulage of ore include an all-weather road without weight restrictions and a private road not subjected to Shire road closures. There are no existing major roads near the mine site that can support heavy duty road trains to the Port.

A number of haul road options were considered for the Proposal with Option 9 ultimately selected. Each option is described below and shown in Figure 11. The distance for each of the road options is summarised in Table 6. Of note is that options 1 – 6 were taking into consideration a linkage to a hydromet processing plant to be located south of Norseman, which is no longer part of the Proposal.

Table 6: Distance from the Proposal to the Port

Option	Description	Location of hydromet plant	Total distance to Esperance Port (km)
1	New Road on L63/68 and upgrades to Lake King Road	Onsite	205
2	Upgrade Honman Track to Windy Hill Camp and Hyden - Norseman Roads	14 km south of Norseman	397
3	Extension of the Exploration Baseline Track to Hyden – Norseman Road		327
4	New Road East to Coolgardie - Esperance Highway - North		290
5			286

Option	Description	Location of hydromet plant	Total distance to Esperance Port (km)
6	New Road East to Coolgardie - Esperance Highway – South	45 km south of Norseman	235
7		None proposed	232
8			220
9			224

Option 1 – New Road on L63/68 and Upgrade to Lake King Road

This is the shortest option however it is based on the assumption that all processing would be conducted at the mine site. It would require vegetation clearing for construction of a new road on L63/68 (tenement now withdrawn) and a significantly re-build on the Lake King Road before ultimately connecting to Port via the Coolgardie – Esperance Highway (Figure 11). Approximately 101 km of road would need to be constructed/upgraded.

Lake King Road is in poor repair as it has not been graded for several decades. A major floodway crosses Lake King Road and a Telstra optic fibre cable runs underneath it. Lake King Road is used by recreational 4wd vehicles and hikers to access Peak Charles.

This option was rejected for several reasons:

- A significant amount of native vegetation clearing is required to construct the new road on L63/68 and upgrade Lake King Road (the most vegetation clearing of all options considered);
- Lake King Road is in poor repair and there is a major floodway that crosses the road therefore considerable work is required to repair the road and construct a new culvert/bridge;
- Telstra was concerned that heavy haulage would compress the optic fibre cable underneath Lake King Road and affect bandwidth and therefore did not support the use of the road;
- Lake King Road is not an all-weather road and subject to closure by the Shire through rain events and fires and has weight restrictions; and
- There is high risk of vehicle collisions with recreational users.

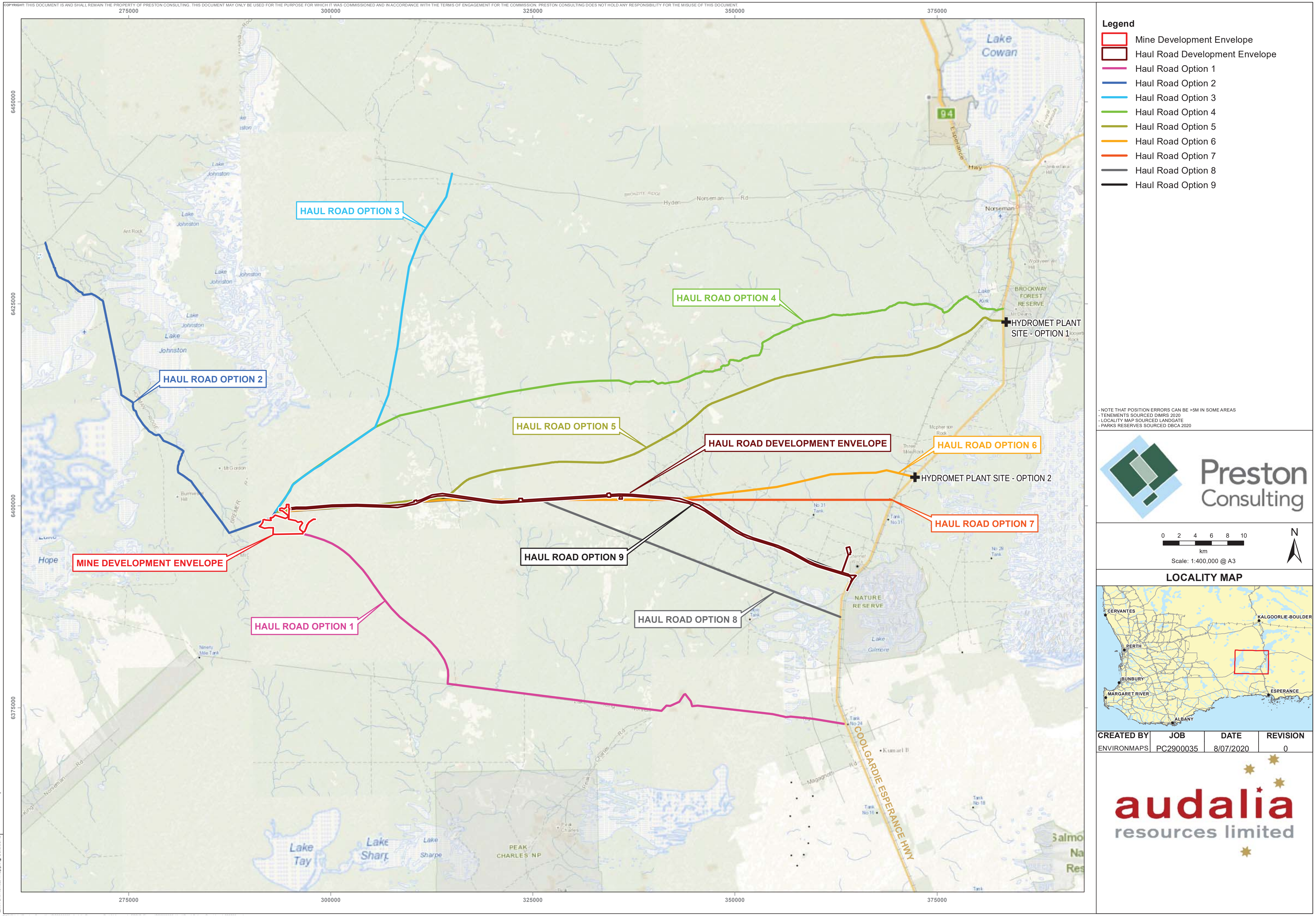


Figure 11: Road to port options considered

Option 2 – Upgrade Honman Track to Windy Hill Camp and Hyden-Norman Roads

This option is to transport ore via the Honman Track then Windy Hill Camp Road and Hyden - Norseman Road (unsealed) (Figure 11). The route then travels through Norseman to a proposed Hydromet plant and ultimately connects to Port via the Coolgardie – Esperance Highway. The route is the longest of all options considered. The Homan Track passes over the Honman Ridge and around salt lakes. The track is extremely rough and has not been maintained and is impassable in wet weather.

This option was rejected for several reasons:

- This is the longest of all routes increasing vehicle emissions, and operational and maintenance costs;
- Honman Track would require a major upgrade to support heavy duty road trains;
- Hyden – Norseman Road has weight restrictions and is subject to Shire road closures;
- Noise restrictions and traffic issues would be expected when travelling through the Norseman township;
- There are landscape values (particularly the Honman ridge and the salt lakes) that could be impacted by dust emissions;
- The road passes through tenements of multiple landowners that would require extensive consultation and negotiation; and
- Windy Hill Camp Road would require a 50 km extension in an area of particularly high environmental and indigenous values including Honman Ridge, Lake Hope and Lake Johnston.

Option 3 – Extension of the Exploration Baseline Track to Hyden – Norseman Road

This option was based on using an existing exploration track northeast of the Proposal for a distance of approximately 15 km then clearing a new track for approximately 35 km connecting to the Hyden – Norseman Road north of Norseman (Figure 11). The route then travels through Norseman to a proposed hydromet plant and ultimately connects to Port via the Coolgardie – Esperance Highway.

This option was rejected for several reasons:

- The length of this option is significant increasing vehicle emissions, and operational and maintenance costs;
- Hyden – Norseman Road has weight restrictions and subject to road closures;
- Granite landforms are close to the road that have high indigenous values;
- Significant amount of native vegetation clearing required; and
- Noise restrictions and traffic issues would be expected when travelling through the Norseman township.

Options 4 and 5 – New Road to Coolgardie - Esperance Highway - North

These options require construction of a new road in a northern direction from the mine site connecting to the Coolgardie – Esperance Highway near Lake Kirk, then to a proposed Hydromet plant. The road trains would then travel a significant distance down the highway to the port. The options were rejected as the length is still considerably long and indirect increasing native vegetation clearing, vehicle emissions, and operational and maintenance costs.

Options 6 - 9 - New Road East to Coolgardie - Esperance Highway - South

Options 6 - 9 are from the mine site travelling east to the Coolgardie - Esperance Highway which ultimately connects to the Port (Figure 11). These options require native vegetation clearing although do not pass through the town of Norseman. Option 9 requires the least new clearing of vegetation as it follows Audalia's exploration access track formed during 2018.

The reasons for the rejection of options 6 - 8 were:

- There was no utilisation of existing tracks and therefore 72.5 km of clearing would be required; and,
- They infringe on granite outcrops and salt lakes that have been identified as having Aboriginal heritage values.

The reasons for **the selection** of Option 9 are:

- It can be developed and operated as a fully private road, allowing larger haul trucks and removing the risks associated with heavy haulage in proximity to the general public;
- The route avoids landforms of ecological and Aboriginal heritage importance such as granite outcrops and salt lakes;
- It requires the least new clearing of vegetation as it follows Audalia's access track formed during the exploration phase of the Proposal.
- It does not cross public roads reducing the likelihood of collisions with the general public; and,
- It follows Audalia's exploration access track formed during 2018

Options Assessment

An options assessment for ore transportation is summarised in Table 7.

Table 7: Options analysis summary

Option	Engineering	Environmental	Heritage	Distance	Safety	Other Factors
Slurry Pipeline	Significant capital cost	Significant Clearing Required	-	Acceptable	Avoids road crossings and interaction with general public	-
Road option 1	Significant engineering required for road repair and new bridge / culvert	Significant Clearing Required	-	Acceptable	Recreational 4wd vehicles and hikers	Telstra fibre optic cable Subject to road closures
Road option 2	Significant engineering required for road upgrade Road weight restrictions	Significant clearing required Potential impacts to Honman ridge and nearby lakes	Potential impacts to Honman ridge and nearby lakes	The longest of all options	Passes through Norseman and multiple landowners	Subject to road closures

Option	Engineering	Environmental	Heritage	Distance	Safety	Other Factors
Road option 3	Road weight restrictions	Significant clearing required Potential impacts to granite landforms	Potential impacts to granite landforms	Significantly long option	Passes through Norseman and multiple landowners	Subject to road closures
Road options 4 and 5		Significant clearing required	-	Indirect route	-	Passes through Norseman and multiple landowners
Road options 6 to 8	No significant issues	Significant Clearing Required	-	Acceptable	Increase risk of collisions at Lake-King Norseman Road	Acceptable commuting distance for local workforce
Road option 9	No significant issues Utilises existing tracks	Clearing reduced as utilise existing tracks Avoids significant landforms	-	Acceptable	No significant issues	Acceptable commuting distance for local workforce

Based on the above options assessment, the preferred option was to construct a private haul road directly east (road option 9) and design the road to ensure it avoided areas of higher ecological or heritage values.

2.4 Local and Regional Context

The Proposal is located in the Bremer Range, Lake Johnston region of WA, approximately 100 km southwest of Norseman (Figure 1). The region has good existing infrastructure and logistical access, including:

- Regional centres of Norseman, Kalgoorlie, Coolgardie and Esperance;
- Norseman Airport;
- Sealed Coolgardie-Esperance Highway; and
- Esperance Port.

The Proposal will link with existing transport and export infrastructure via the Coolgardie - Esperance Highway, with product proposed to be exported through Esperance Port.

2.4.1 Land Use

The Proposal lies on land held by the Ngadju people, who have lived on country between Kalgoorlie and Esperance for an estimated 50,000 years. The Proposal lies within the Ngadju Native Title determination area.

The Proposal lies on Unallocated Crown Land (UCL) with the exception of the building and intersection to connect to the Coolgardie - Esperance Highway (74 km east of the mining area), which will occur within the road corridor.

The mine site lies to the south of a cluster of exploration leases issued under the Mining Act, including three Audalia exploration leases (Figure 12). This area has been extensively explored since the 1960's for nickel and during 2001, LionOre commenced a major mining operation for the production of nickel. During 2007 Norilsk Nickel purchased the operating mine which finally close due to falling nickel prices during 2011. This minesite lies 50 km north of Medcalf now owned by Poseidon Nickel since 2014 and is currently on care and maintenance.

2.4.2 Environmental Assets

The Mine DE and the western portion of the Haul Road DE lie within the proposed Bremer Range Nature Reserve which has a total area of 50,920 ha (Figure 13). The proposal for a Bremer Range Nature Reserve by Henry-Hall *et al.* (1990) was formally adopted as a proposal by the then Department of Conservation and Land Management in its South Coast Region Regional Management Plan (Anon., 1992). Conservation of endemics such as *Eucalyptus rhomboidea* (Priority 4 species) was included as part of the justification for the proposed nature reserve. The proposal to create the Bremer Range Nature Reserve has yet to be enacted by Government (predominantly due to mineralisation in the area), and it is not listed under the EPA Red Book recommendations for Conservation Reserves 1976-1991 (Department of Biodiversity Conservation and Attractions (DBCA), 2019b).

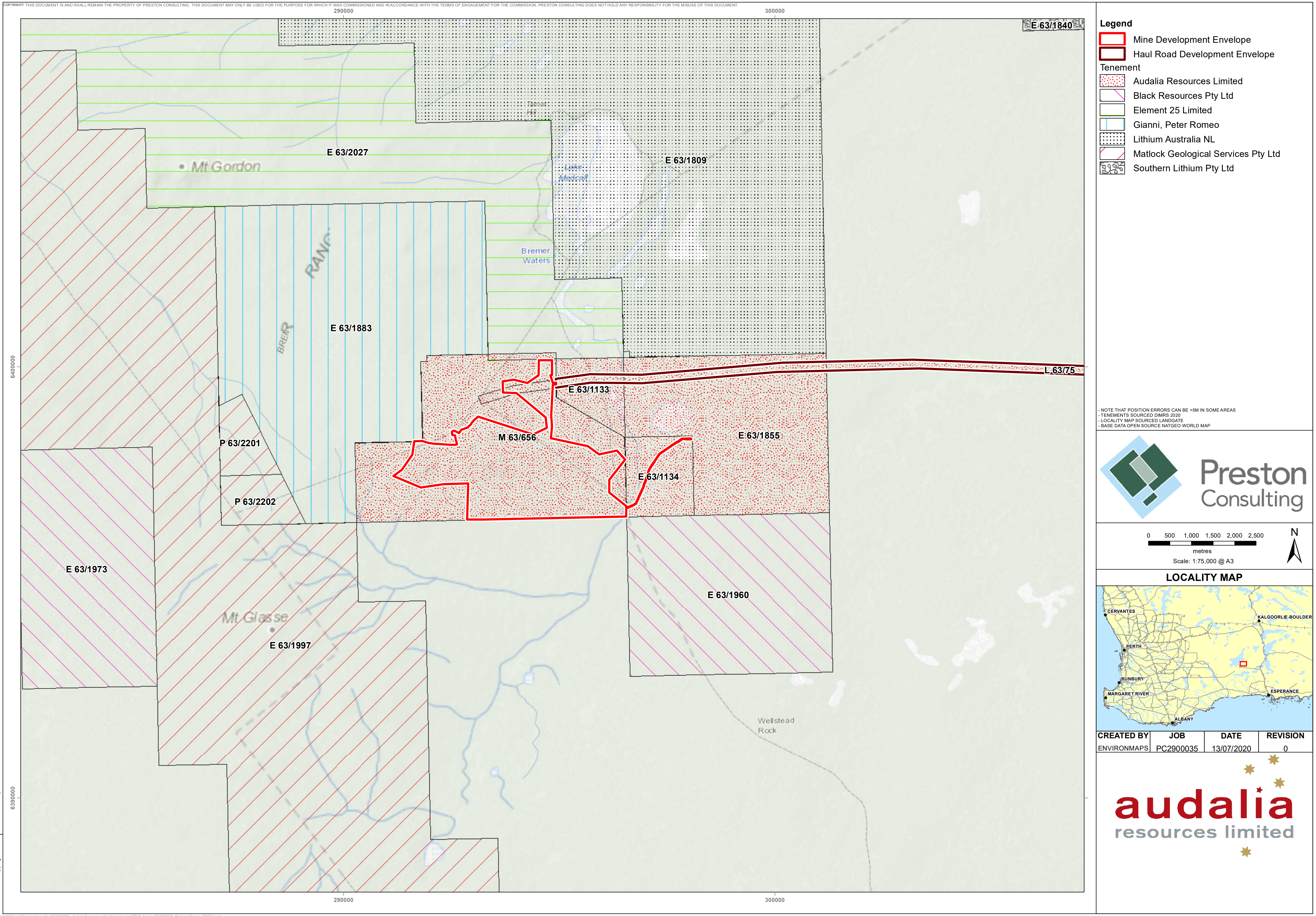
The Mine DE and 8.2 km of the Haul Road DE lie within the *Bremer Range vegetation complexes* Priority 1 Ecological Community (PEC) and its buffer (Figure 13). This PEC is associated with three ridges; Mt Day, Round Top Hill and Honman Ridge), all of which lie 55, 50 and 20 km respectively north west of the DE.

The Bremer Range, which lies 5 km to the north-west of the Proposal, is of significant biodiversity value due to the presence of endemic plant taxa, rare and restricted plant taxa and highly restricted and distinct plant communities. The Range has very distinct features in the regional landscape and in many cases possesses outstanding landscape values (Gibson & Lyons, 1998a).

The Proposal lies within the Great Western Woodlands, which covers an area of 16 million hectares. It is considered to be an internationally significant area of great biological richness and contains the largest remaining area of intact Mediterranean-climate woodland on Earth (DEC, 2010a).

The DEs contain a number of Priority Flora under the BC Act and intersects with a portion of habitat for *M. aquilonaris*, a Threatened Flora under the BC Act.

The Proposal DEs do not contain any conservation reserves, Threatened Ecological Communities (TECs) or listed wetlands.



CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900035	13/07/2020	0

audalia resources limited

ENVIRONMAPS Environmental Mapping Solutions t 0406 590 006 www.environmaps.com.au

Figure 12: Regional tenure

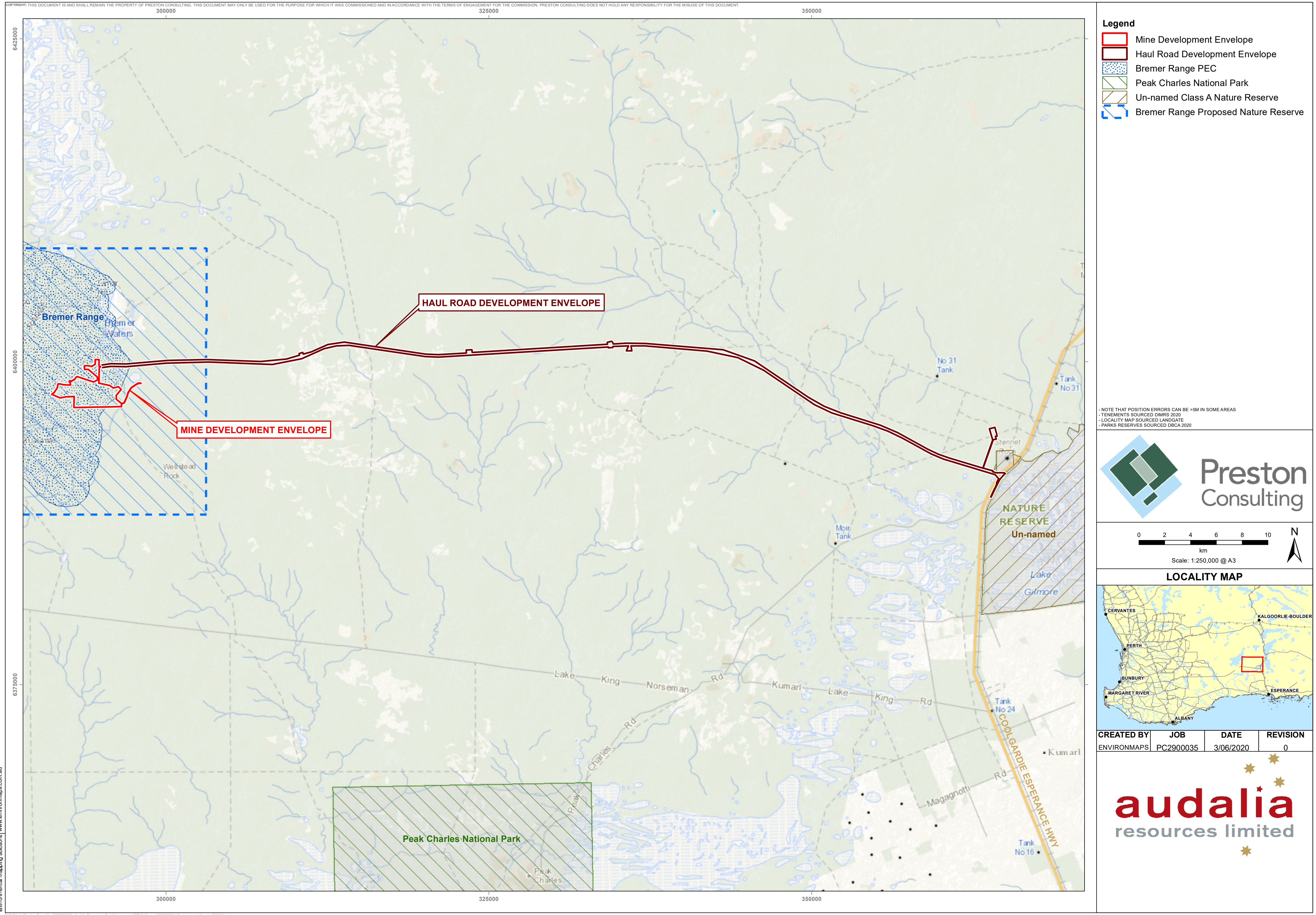


Figure 13: Environmental assets

3 STAKEHOLDER ENGAGEMENT

3.1 KEY STAKEHOLDERS

3.1.1 GOVERNMENT STAKEHOLDERS

Commonwealth, State and Local Government authorities have been briefed on the Proposal to ensure any issues, concerns or suggestions are identified and, where appropriate, addressed or responded to by Audalia. The consultations have resulted in some changes to the Proposal design; however, in most cases the purpose was to provide the Government stakeholder with relevant information.

The following Government stakeholders were deemed to be relevant to the Proposal:

- Commonwealth:
  - DAWE;
- State:
  - DBCA;
  - DMIRS;
  - DWER (EPA Services, Industry Regulation, Water);
  - Department of Jobs, Tourism, Science and Innovation;
  - Department of Transport;
  - Department of Planning, Lands and Heritage;
  - Department of Primary Industries and Regional Development (DPIRD);
  - Southern Ports Authority;
  - MRWA;
  - Minister for Mines;
  - Minister for Regional Development;
  - Minister for State Development;
  - Minister for the Environment and Water;
- Local:
  - Shire of Dundas; and
  - Shire of Esperance.

3.1.2 TRADITIONAL OWNERS, CORPORATE AND COMMUNITY STAKEHOLDERS

Audalia recognises that Traditional Owners, individuals, companies and communities may also be interested in the impacts of the Proposal. The following Traditional Owners, corporate and community stakeholders were deemed to be relevant to this Proposal:

- Ngadju People;
- Australian and New Zealand Environment and Conservation Council;
- Australian Nature Conservation Agency / Australian Wildlife Conservancy;
- Birds Australia / Birdlife Australia;
- Conservation Council of WA;
- Gondwana Link Ltd;
- Greening Australia;
- Optus Pty Limited;
- Telstra Corporation Limited;

- Threatened Species Scientific Committee (part of DAWE);
- Wilderness Society (WA); and
- Wildflower Society (WA).

3.2 STAKEHOLDER ENGAGEMENT PROCESS

Audalia has a Consultation Strategy which identifies key external stakeholders and determines how they will be impacted by the Proposal and what influence they have over its implementation. The aim of the consultation is to develop productive relationships that ensure the Proposal is underwritten by sustainable agreements and necessary statutory approvals. The Consultation Strategy has also been developed to secure the approvals necessary for the construction and operation of the Proposal, which will require consultation with the following stakeholders:

- Local Government (including Shire);
- State Government;
- Ngadju People with a connection to the land; and
- Corporate and community stakeholders.

3.3 STAKEHOLDER CONSULTATION

Audalia has a Stakeholder Consultation Register which maintains records of all consultations with stakeholders. This register summarises key issues raised by stakeholders during the consultation process and describes how Audalia has responded to those issues. A summarised version of the Stakeholder Consultation Register is provided in Table 8 to supply details of the stakeholder consultation undertaken to-date for the Proposal. Generic discussions with decision-making authorities have not been included as per the guidance provided in EPA (2020b).

The Proposal is situated on land that is subject to a determination of native title in favour of the Ngadju People (*Graham on behalf of the Ngadju People v State of Western Australia [2014] FCA 1247*). The Ngadju People is the sole native title holders in the area encompassing the Proposal. Audalia has engaged with the Ngadju People extensively since the beginning of project planning. The consultations with the Ngadju People include but are not limited to the following:

- Archaeological and ethnographic heritage survey undertaken in September 2012 over the Proposal mining tenement (M63/656);
- Heritage survey undertaken in September 2015 to confirm whether the rock shelters on the eastern side of the Fuji deposit are of significance pursuant to Section 5 of the *Aboriginal Heritage Act 1978*. The survey results confirmed that they were not of significance pursuant to Section 5;
- Various native title negotiation meetings held with GLSC in January, February, March, April, May, September and October 2015;
- A definitive land access agreement signed with the Ngadju People on 9 November 2015, in relation to the grant of Proposal tenure, development of the Proposal and conduct of the Proposal operations;
- Meetings on heritage protocol revision held in July 2017;
- Letter on bush tucker and bush medicine sent in July 2017. No specific areas of bush tucker or bush medicine were identified;
- Anthropological heritage survey undertaken in November 2017 for a 4 m wide exploration access track within the proposed haul road corridor. No sites were identified;

- Anthropological heritage survey undertaken in January 2018 for a 60 m wide haul road corridor within L63/75. No sites were identified.
- Letter regarding proposed ERD lodgement sent in May 2020;
- Notification letter regarding ERD lodgement and meeting invitation sent in July 2020; and
- Proposal update presentation sent in July 2020.

A Stakeholder Consultation Plan is also maintained by Audalia. This plan outlines the key stakeholders, type of consultation, purpose of the engagement, issues / subjects to be raised and the timing of those engagements. A summarised version of the Stakeholder Consultation Plan is provided in Table 9 to supply details of the planned future and ongoing stakeholder consultation relevant to the Proposal and this ERD.

Table 8: Stakeholder Consultation Register

Stakeholder	Date/s	Issues / Topics Raised	Proponent Response / Outcome
Government Stakeholders			
DAWE	2 November 2017 - Meeting 24 November 2017 – Letter 4 December 2017 - Email 9 January 2018 - Letter	• Pre-referral discussion • Matters of National Environmental Significance • Referral under the EPBC Act • Determination: Not a Controlled Action	No further action required – Not a Controlled Action.
DWER – EPA Services	October 2015 August (meeting), December 2017 March (letter), June, July (meeting), October (email), November (email), December (email) 2018 February (email, letter and meeting), March, July, August 2019 February 2020	• Environmental survey effort requirements and findings • Pre-referral discussions • Exploration activities • Priority and Threatened Flora populations • Formal submission of EPA Referral • Formal submission of the draft ESD • Draft ESD submitted with peer review • Formal submission of the revised draft ESD • Impacts to proposed Bremer Range Nature Reserve • Methodologies for *M. aquilonaris* studies • Clearing permit for investigations • Clarification on ESD process if *Eucalyptus rhomboidea* and *Stenanthemum bremerense* are made threatened species • ESD updated to incorporate peer review comments • Assessment and comments on ESD • Review *M. aquilonaris* study results • *M. aquilonaris* critical habitat boundary	• Concerns taken on board during ERD preparation. • Advice in *Eucalyptus rhomboidea* and *Stenanthemum bremerense* included in ESD revision • Audalia to continue to liaise during Part IV approval process.
DWER – Industry Regulation	April 2020 (meeting)	• Project briefing and update • Regulation under Part V of the EP Act • Parallel processing with Part IV assessment	• Audalia to submit works approval applications for parallel processing towards the end of the EIA process

Stakeholder	Date/s	Issues / Topics Raised	Proponent Response / Outcome
DMIRS	June (letter), July (letter and meeting), August, October (letter) 2014 February (meeting), April (meeting), May (meeting), June (letter), July (meeting), December (meeting) 2015 March (meeting) 2016 September 2017 July (email), November (meeting) 2018 March (teleconference) 2020	• Project overview and updates • Project access • Mining tenure applications • Safety Management Plan • Priority and Threatened Flora populations • Conservation Management Plan • Exploration activities and approvals • MP and MCP • Pre-referral discussions • Clearing permit for investigations • Review of conceptual TSF design • MCP to be submitted with ERD	• MCP to be submitted to allow parallel assessment with the Part IV EP Act process. • MP and MCP to be prepared in accordance with DMIRS guidelines.
DBCA	July 2013 (letter) March (meeting), April (email), May (letter), August, October (letter) 2014 April (meeting), May (meeting), July (meeting and letter), October 2015 March (meeting), May (letter), June (letter) 2016 January, March, June (email), September (site visit), October (email), November (meeting) 2018 January (meeting), March, July, December 2019 February, July 2020	• Project overview and updates • Priority and Threatened Flora populations • Permit to take Threatened Flora • Conservation Management Plan • Exploration activities and approvals • Update on Mining Plan • Project access • Environmental study and survey effort requirements and findings • Pre-referral discussions • Impacts to proposed Bremer Range Nature Reserve • ESD draft flora and vegetation section • Methodologies for *M. aquilonaris* studies • Notification that *Eucalyptus rhomboidea* and *Stenanthemum bremerense* may be nominated as threatened species • Location of dust deposition gauges • Scope of proposed modelling of M. aquilonaris locations	• Comments addressed in ESD • Provision of study works information for PoW. Studies undertaken in agreed manner • *Eucalyptus rhomboidea* and *Stenanthemum bremerense* considered in project planning and studies • Audalia to continue to liaise with DBCA during the Part IV approval process

Stakeholder	Date/s	Issues / Topics Raised	Proponent Response / Outcome
		• Genetic study for *M. aquilonaris* • Review *M. aquilonaris* study results • *M. aquilonaris* critical habitat boundary • Proposed offsets	
Shire of Esperance	April, June (letter), August 2014 April 2016	• Project Overview • Access road and road upgrades • Shipping out of the Esperance Port • Discussion of DMIRS concerns • Notification of release of Project Pre-feasibility Study (PFS) report	Audalia to continue to liaise with the Shire and to obtain required approvals.
Shire of Dundas	June 2015 (meeting) April 2016 (letter)	• Project Overview • Potential mining and processing plant operation • Proposal of private haul road and rational • Future engagement with Shire • Potential upgrade of airport • Notification of release of PFS report	Audalia to continue to liaise with the Shire and to obtain required approvals.
Southern Ports Authority	January, February 2017	• Enquiry about port access by mineral exporter • Visit to Esperance Port and discussion with Port Chief Executive Officer Alan Byers on port access by Audalia • Port infrastructures availability and requirements for new exporter	Audalia to continue to liaise with the Southern Ports Authority and to obtain required approvals.
Goldfields-Esperance Development Commission	April 2016 (letter)	Notification of release of PFS report	Audalia to continue to liaise with the Commission and provide project update.
Traditional Owner, Community and Corporate Stakeholders			
Ngadju People	September 2012 (meeting) January - May, September, October 2015 (meetings) July (letter), November 2017 (meeting) July 2020 (letter)	• Proposal overview and updates • Ethnographical survey • Ethnographic and Anthropological heritage surveys, including over M63/656 and L63/75, undertaken with the assistance of nominated Ngadju Native Title Holders • Negotiation and community meetings • Consultation of bush tucker and medicine in the proposal area	Audalia to meet with stakeholder and / or provide additional information upon request

Stakeholder	Date/s	Issues / Topics Raised	Proponent Response / Outcome
		• Heritage and native title agreement • Notification of submission of draft ERD	
Conservation Council of WA	Aug 2014 (meeting) May 2015 (meeting) July 2020 (email)	• Project introduction and environmental considerations / issues • Information Pack provided • Offer for meeting or further information • Notification of preparation of draft ERD	Consideration of issues in Proposal design and the preparation of ERD Audalia to meet with stakeholder and / or provide additional information upon request
Gondwana Link Ltd.	Aug 2014 (meeting) July 2020 (email)	• Project introduction and environmental considerations / issues • Information Pack provided • Offer for meeting or further information • Notification of preparation of draft ERD	Consideration of issues in Proposal design and the preparation of ERD Audalia to meet with stakeholder and / or provide additional information upon request
Main Roads WA	July 2017 (letter) March 2020 (phone)	• Application and approval for highway access – Coolgardie Esperance Highway • Proposal updates of Goldfields Esperance region provided	Audalia to meet with stakeholder and / or provide additional information upon request
Optus Pty Limited	April 2014	• Fibre optic cables within the vicinity of the proposed haul road	Haul road Option 9 was chosen to avoid impact to fibre optic cables.
The Wilderness Society (WA) Inc.	Aug 2014 (meeting) May 2015 (meeting) July 2020 (email) August 2020 (meeting)	• Project introduction and environmental considerations / issues • Information Pack provided • Offer for meeting or further information • Notification of preparation of draft ERD	Consideration of issues in Proposal design and the preparation of ERD Audalia to meet with stakeholder and / or provide additional information upon request
Wildflower Society of WA	May 2015 (meeting) July 2020 (email)	• Project introduction and environmental considerations / issues • Information Pack provided • Offer for meeting or further information • Notification of preparation of draft ERD	Consideration of issues in Proposal design and the preparation of ERD Audalia to meet with stakeholder and / or provide additional information upon request

Table 9: Stakeholder Consultation Plan

Timing	Stakeholder	Type	Purpose of planned engagement	Issues to be raised
2020 - ongoing	EPA Services - DWER	Telephone, letters, email and meetings	• Correspondence during assessment under Part IV of the EP Act • EPA Board meeting	• Presentation of EIA • Review of draft ERD • Response to public comments • Draft conditions • EPA Board meeting • Compliance
2020 - ongoing	Industry Regulation - DWER	Telephone, letters, email and meetings	Correspondence to obtain works approvals under Part V of the EP Act.	• Future Works Approvals and Licence requirements • Proposal timing (i.e. construction) • Potential environmental impacts • Compliance
2020 - ongoing	DMIRS	Telephone, letters, email and meetings	Correspondence to obtain approval for PoWs, MP, MCP and Project Management Plan	• Tenement applications • MP and MCP assessment • Timing • Project specific requirements • Closure requirements • Project Management Plan assessment • Compliance and Reporting • Mine Rehabilitation Fund
2020-ongoing	DBCA	Telephone, letters, email and meetings	Advice into ongoing management of Proposal within close proximity to Threatened and Priority Flora	• Threatened and Priority Flora • Proposed Nature Reserve • PEC • Great Western Woodlands
2020 - ongoing	Main Roads WA	Telephone, letters, email and meetings	Discussions regarding intersection works and haulage	• Future applications • Site access • Timing (i.e. construction & operation) • Operating hours • Site access/routes
2020 - ongoing	Department of Transport	Telephone, letters, email and meetings	Discussions regarding haulage	• Future applications • Timing (i.e. construction & operation) • Site access/routes
2020 - ongoing	Southern Ports Authority	Telephone, letters, email and meetings	Correspondence to negotiate terms for the export of ore through Esperance Port	• Future applications • Export options

Timing	Stakeholder	Type	Purpose of planned engagement	Issues to be raised
				• Path forward for the Proposal
2020	Relevant Ministers	Letters and meetings	Letter summarising the Proposal status (i.e. approvals to date and path forward).	• Approvals status • Future applications • Studies undertaken • Key findings • Path forward for the Proposal
2020 - ongoing	Shire of Dundas	Telephone, letters, email and meetings	Correspondence summarising the Proposal status (i.e. approvals to date and path forward).	• Approvals required • Future applications • Path forward for the Proposal • Local workforce availability
2020 - ongoing	Shire of Esperance	Telephone, letters, email and meetings	Correspondence summarising the Proposal status (i.e. approvals to date and path forward).	• Export through Esperance Port • Path forward for the Proposal • Local workforce availability
2020 - ongoing	Ngadju People	Letter and copies of approval documents	Feedback on Proposal design.	• Approvals to date • Future applications • Studies undertaken and key findings • Path forward for the Proposal • Potential for indigenous contracting and employment opportunities • Bush tucker/ bush medicine management
2019 - ongoing	Non-government organisations and community groups	Telephone, letters, email and meetings	Input and provision of information	• Provision of ecological information • Invitation for comment • Threatened and Priority Flora • Great Western Woodlands • PECs • Proposed Bremer Range Nature Reserve

4 ENVIRONMENTAL PRINCIPLES

The EP Act identifies a series of principles for environmental management (Section 4a, EP Act, as amended). Audalia has considered these principles in relation to the development and implementation of the Proposal. Table 10 outlines how the principles relate to the Proposal.

Table 10: EP Act Principles

Principle	How it will be addressed by the Proposal
1. The precautionary principle Where there are threats of serious 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.	While Audalia has commissioned numerous studies in order to inform the design of the Proposal, there are still several examples where a precautionary approach has been taken, such as: • Exclusion of Threatened Flora populations and the majority of their critical habitat from the DEs; and • Relocation of infrastructure away from known Threatened and Priority Flora records, reducing impacts on areas with greater biodiversity.
2. The principle of 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.	The Proposal has been designed with a constrained disturbance footprint, specifically targeted to avoid all Threatened Flora records and the majority of Priority Flora records. Surveys and research conducted for *M. aquilonaris* during the study phase has built on existing knowledge base and will allow more informed management of this species for the benefit of future generations.
3. The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integration should be a fundamental consideration.	Survey work has been used to confirm the range and status of environmental values within the study areas. Conservation of biological diversity and ecological integration was considered when developing the boundaries of the proposed DEs, with key ecological features removed from the DEs wherever practicable.
4. Principles relating to improved valuation, pricing and incentive mechanisms 1) Environmental factors should be included in the valuation of assets and services. 2) The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. 3) The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. 4) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which benefit and/or minimise costs to develop their own solutions and responses to environmental problems.	As discussed in Section 2.3.4, the Proposal mine plan, design and management controls have been revised to reduce the potential impacts to environmental factors. These revisions resulted in additional costs or sterilised resources that have been considered in the Proposal costing phases and this will continue through the final feasibility stages of the Proposal.
5. The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Waste will be minimised by adopting the hierarchy of waste controls; avoid, minimise, re-use, recycle and safe disposal.

Principle	How it will be addressed by the Proposal
	There are several examples of how the Proposal will minimise the generation of waste and its discharge to the environment: • Use of waste rock for TSF embankment construction and rehabilitation • Use of brackish groundwater in processing, which avoids the production of brine from reverse osmosis processes • Waste generated from the Proposal will be classified and sorted before disposal • Waste such as cardboard, aluminium, scrap metal, poly pile and pallets will be recycled off-site • Office and packaging waste such paper, cardboard and plastics will be recycled off-site • Putrescible waste from kitchens/messes and construction waste, i.e. bricks, concrete, timber, plasterboard, gyprock, tiles, will be disposed to a dedicated landfill facility onsite

5 FLORA AND VEGETATION

5.1 EPA Objective

The EPA Objective for this key environmental factor is to protect flora and vegetation so that biological diversity and ecological integrity are maintained.

5.2 Policy and Guidance

Relevant EPA guidance documents for flora and vegetation are listed below:

- Statement of Environmental Principles, Factors and Objectives (EPA, 2020a);
- Environmental Factor Guideline for Flora and Vegetation (EPA, 2016c);
- Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016d);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA, 2016a);
- EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2020c);
- Environmental Protection Bulletin 20 - Protection of naturally vegetated areas through planning and development (EPA, 2013); and
- Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006).

Other relevant policy and guidance documents for flora and vegetation are listed below:

- WA Environmental Offsets Guidelines (EPA, 2014);
- WA Environmental Offsets Policy 2011 (EPA, 2011); and
- *M. aquilonaris* Interim Recovery Plan 2010-2014. Interim Recovery Plan No. 303 (DEC, 2010b).

5.3 Receiving Environment

The text in this section has been sourced from Botanica Consulting (Botanica; 2020c and 2020e) unless stated otherwise (Appendix 3.9 and 3.11).

5.3.1 Survey Effort

A desktop assessment and field surveys for flora and vegetation have been conducted over the Mine DE and Haul Road DE proposed in this ERD. Additional studies were conducted to assess soil characteristics and habitat of the threatened flora species *M. aquilonaris.*

Desktop Assessment

Prior to the field assessment a literature review was undertaken of previous flora and vegetation assessments conducted within the local region, including:

- Vegetation Survey and Rare Flora search on the Vesuvius Prospect Medcalf Project (Armstrong, 2012);
- Flora of Conservation Significance Search of the Medcalf Exploration Project, May 2013 (Botanica, 2013);
- Level 2 Flora & Vegetation Survey for the Medcalf Vanadium Mining Project Spring 2013 to Autumn 2015 (Botanica, 2015);

- Biological Survey and Environmental Assessment of the Emily Ann Project Area (Brearley et al, 1998);
- Flora and Vegetation of the Eastern Goldfields Ranges: Part 2 (Gibson & Lyons, 1998b); and
- The Biological survey of the Eastern Goldfields of Western Australia: Part 4. Lake Johnston-Hyden Study Area (How et al, 1988).

Searches of the following databases were undertaken to aid in the compilation of a list of flora taxa and assess the conservation significance of flora/ vegetation within the survey area:

- DBCA Priority/ Threatened Flora Database Search (DEC, 2013a; Department of Parks and Wildlife (DPaW; 2017a);
- DPaW Priority/ Threatened Ecological Communities Database Search (DEC, 2013b; DPaW, 2017b);
- DBCA NatureMap Database (DPaW, 2017c); and
- DAWE Protected Matters search tool (Department of the Environment and Energy (DotEE; 2017a).

The conservation significance of flora and vegetation was assessed using data from the following sources:

- EPBC Act - administered by the Australian Government (DAWE);
- BC Act - administered by the WA Government (DBCA);
- Red List produced by the Species Survival Commission of the World Conservation Union (also known as the International Union for Conservation of Nature (IUCN) Red List). The Red List has no legislative authority in Australia but is used as a framework for State and Commonwealth categories and criteria; and
- DBCA Priority Flora and Communities list - a non-legislative list maintained by DBCA for management purposes.

Potential Groundwater Dependant Ecosystems

A search of the Bureau of Meteorlogy (BoM) *Atlas of Groundwater Dependent Ecosystems* database (BoM, 2017) was conducted to assess the potential for Groundwater Dependent Ecosystems (GDEs) to occur within the survey area. A GDE refers to ecosystems that rely on groundwater for some or all of their water requirements (Geoscience Australia, 2017). According to the database, there are two potential GDE classes:

1. Aquatic ecosystems that rely on the surface expression of groundwater – this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs; and
2. Terrestrial ecosystems that rely on the subsurface presence of groundwater – this includes all vegetation ecosystems.

A low potential for groundwater interaction means that ecosystems 'are relatively unlikely to be interacting with groundwater. This includes ecosystems that are not interacting with groundwater' (Australian Government, 2012). High potential for groundwater interaction means that 'there is a strong possibility that ecosystems are interacting with groundwater' (Australian Government, 2012).

The assessment of GDE Potential categories specified in the database are based on the physical landscape and ecosystem characteristics as specified by the following rules (Australian Government, 2012):

- Rule 1: Vegetation that demonstrates an evapotranspiration that is higher than rainfall is more likely to be using groundwater;
- Rule 2: Vegetation that intersects with a spring is likely to be using groundwater;
- Rule 3: Vegetation is more likely to be using groundwater in areas where the watertable is shallow;
- Rule 4: Vegetation growing in areas where water stored in the unsaturated zone is limited, is more likely to be using groundwater; and
- Rule 5: Certain vegetation communities are more likely to access groundwater than others.

Detailed Flora and Vegetation Field Surveys

The inaugural detailed flora and vegetation survey of the mining area was conducted in spring 2013; 62 quadrats were established and re-surveyed in autumn 2014. In spring 2014, the survey area was expanded with a further 30 quadrats established. These quadrats were re-surveyed in autumn 2015.

A detailed flora and vegetation survey of the proposed haul road was conducted in autumn 2017, with 35 quadrats established. These quadrats we re-surveyed in spring 2017.

A total of 127 quadrats were established within the 18,770 ha survey area (mine site and haul road inclusive). Figure 14 shows the extent of the survey area, and Appendix 3 of Botanica (2020c) provides more detail on the location of these quadrats with respect to each vegetation type.

Prior to the field survey, a combined search of the DBCA Flora of Conservation Significance databases (DEC, 2013a; DPaW, 2017a) and DBCA Priority/ Threatened Ecological Communities database was undertaken within a 60 km radius of the survey area. Significant flora species identified through the database search were examined on the WA Herbarium's web page prior to the survey, to familiarise staff with their appearance. Locations of Threatened Flora and Priority Flora were overlaid on aerial photography of the area. Vegetation descriptions and available images of the Threatened / Priority Flora were also obtained from Florabase.

Prior to the commencement of field work, aerial photography was inspected and obvious differences in the vegetation assemblages were identified. The different vegetation communities identified were then inspected during the field survey to assess their validity. A handheld GPS unit was used to record the coordinates of the boundaries between existing vegetation communities. At each sample point, the following information was recorded:

- GPS location;
- Photograph of vegetation;
- Dominant taxa for each stratum;
- All vascular taxa (including annual taxa);
- Landform classification;
- Vegetation condition rating;
- Collection and documentation of unknown plant specimens; and
- GPS location, photograph and collection of flora of conservation significance if encountered.

Unknown specimens collected during the survey were identified with the aid of samples housed at the Botanica Herbarium and WA Herbarium. Floristic communities were classified in accordance with the National Vegetation Information System (NVIS) (Level V) Floristic Community Type classification. The survey area was traversed by three people via 4WD, all-terrain vehicle and on foot.

<u>Sampling Quadrats</u>

A total of 127 20 m x 20 m quadrats were established within the survey area. In accordance with EPA (2016d) guidance, the objective was to have at least three quadrats per vegetation type to capture the floristic variations within the survey area. Where a community was insufficiently large to accommodate three quadrats, the maximum number of quadrats that would fit within that specific community was established. The quadrats were established by inserting metal pickets in each corner and measuring the length of the resultant boundaries to verify the quadrats were 20 m x 20 m (square quadrats).

Following their establishment and boundary verification, the location of each quadrat was recorded by GPS, photographed and all vascular plants within the quadrat were recorded. This included recording of dominant taxa from the upper, middle and lower stratum, and sampling of all unknown taxa. Unknown taxa were identified using Botanica's own reference herbarium and relevant taxonomical keys or by a taxonomic consultant. Data on level of disturbance, presence of coarse fragments on surface, topographical position, elevation, aspect, percentage litter, percentage bare ground, percentage surface rock (bedrock and surface deposits), soil types (colour, profile, field texture and surface type), and vegetation structure were collected from each quadrat.

Methods of recording data from these quadrats largely follow those outlined in CSIRO's *Australian Soil and Land Survey Field Handbook* (McDonald et al. 1998), the DBCA Recommended Interim Protocol for Flora Surveys of Banded Ironstone Formations (BIF) of the Yilgarn Craton (DEC, 2007) and in accordance with current EPA Guidelines (2016d).

Figure 14: Survey quadrats and development envelopes

Alignment with Technical Guidance

Botanica conducted a review of the implemented survey methods against the relevant EPA technical guidance (EPA, 2016d). The survey methods were deemed to align with the technical guidance however there were some unavoidable limitations due to the area being previously disturbed, analyst skills and knowledge, and completeness of the surveys. Further detail is provided in Table 11 and Table 12.

Table 11: Summary of flora and vegetation survey details

Key points	Compliant?
Preparation for survey Survey led by botanist with at least five years' experience in the bioregion Survey conducted under flora collection licences and landowner permission obtained	Yes
Desktop study (Mine and Road DEs) Relevant databases searched at appropriate search extent. Description of regional setting (e.g. vegetation, land systems and soils).	Yes
Survey (Mine and Road DEs) Level 1 Survey To verify the information obtained from the desktop study, characterise the flora and delineate the vegetation units present.	Yes
Detailed survey (Mine and Road DEs) Level 2 Survey Survey effort – multiple sampling events	Yes
Sampling techniques appropriate i.e. site type, quadrat size, vegetation condition rating	Yes
Survey design Survey area extent appropriate Survey effort – adequate sampling of vegetation Site selection Survey timing appropriate Flora population census	Yes, the surveys conducted for the mine and road DEs were sufficient in their extent, site selection and timing. Targeted flora searches for significant flora were conducted over an expanded area.
Flora Collection and identification of specimens Vouchering New species	Yes
Vegetation Structural vegetation description Floristic composition vegetation classification Vegetation description Defining TECs and PECs	Yes
Mapping	Yes
Reporting	Yes

Table 12: Limitations and constraints associated with the flora and vegetation survey

Variable	Potential Impact on Survey	Details
Access problems	Not a constraint	Access tracks within the survey area were limited, however the area was sufficiently covered through the use of 4WD, all-terrain vehicle and on foot.
Competency / Experience	Not a constraint	The Botanica personnel that conducted the survey were regarded as suitably qualified and experienced. Coordinating Botanist: Jim Williams Field Staff: Jim Williams, Andrea Williams, Lauren Pick, Pat Harton, Matthew Newlands, Alana Butler, Emma Williams Data Interpretation: Jim Williams, Andrea Williams & Lauren Pick
Timing of survey, weather & season	Not a constraint	Survey work has been conducted over multiple years and different seasons in accordance with technical guidelines for flora and vegetation surveys (EPA, 2016d). Surveys were conducted during optimum time when a large number of annual species were present and many species were in flower. Supplementary surveys were also conducted in dry periods as recommended by EPA and additional wet periods. Targeted surveys were conducted over multiple seasons including during optimal flowering / budding periods for significant flora known to occur within the survey area and following above average rainfall to identify cryptic / annual taxa.
Area disturbance	Minor constraint	The survey area has been subject to disturbance from fire over multiple years. Vegetation structure of regrowth vegetation types is subject to change with continued recovery from fire.
Survey Effort / Extent	Not a constraint	Survey intensity was high with a quadrat based detailed survey and targeted surveys conducted over multiple years / seasons. Prior to the quadrats being established a reconnaissance of the survey area was conducted in order to identify vegetation communities and any Flora of Conservation Significance.
Availability of contextual information at a regional and local scale	Not a constraint	Threatened flora database searches provided by the DBCA were used to identify any potential locations of Threatened / Priority Flora species. BoM, DWER, DPIRD, DBCA and DAWE databases were reviewed to obtain appropriate regional desktop information on the biophysical environment of the local region. Environmental assessments within the local region have been limited however Botanica was able to obtain information about the area from previous flora assessments conducted within the Coolgardie region and reconnaissance surveys conducted by Botanica which provided context on the local environment.
Data analysis	Minor constraint	Botanica staff conducting the PATN analyses are not statistical analysts and have basic statistics training. These analyses are able to provide basic information on the relationships between vegetation communities.
Completeness	Minor constraint	In Botanica's opinion, the survey area was covered sufficiently in order to identify vegetation assemblages. The vegetation types for this study were based on visual descriptions in the field. The distribution of these vegetation communities outside the study area is not known, however vegetation types identified were categorised via comparison to vegetation distributions throughout WA specified in the NVIS Major Vegetation Groups (DotEE, 2017b).

Targeted Flora Surveys

Targeted flora surveys for conservation significant flora of the Honman Ridge / Bremer Range area were conducted from 1 - 6 October 2014 by six Botanica staff members. Additional targeted surveys of the Proposal and the Bremer Range area were conducted from 8 - 13 April 2019 by four Botanica staff members. Targeted searches for regional records of two Priority Flora taxa; *Eucalyptus rhomboidea* (P4) and *Stenanthemum bremerense* (P4) were conducted within the Maggie Hays/ Jilbadji and Mt Holland area from 8 - 10 May 2019 by two Botanica staff members.

Botanica visited known regional records (obtained from DBCA Flora database search, 2018) of both species within the Jilbadji, Mt Holland and Maggie Hays area to confirm their location / population size. Potential habitats (based on desktop assessment of geology/ topography and vegetation known to support both species) were also visited.

All records of flora of conservation significance / population boundaries were recorded using handheld GPS (GDA94). The following data was recorded:

- Number of plants of each significant species;
- Population size and boundary of population for widespread / high density species and records; and
- Note if flowering, seeding, juvenile or mature.

Vegetation types identified during the previous flora and vegetation surveys as potentially containing flora of conservation significance were targeted. The target vegetation type / habitat was systematically searched for flora of conservation significance with the area traversed on foot along parallel traverses (between 10 – 50 m apart depending on the density of vegetation; Figure 15).

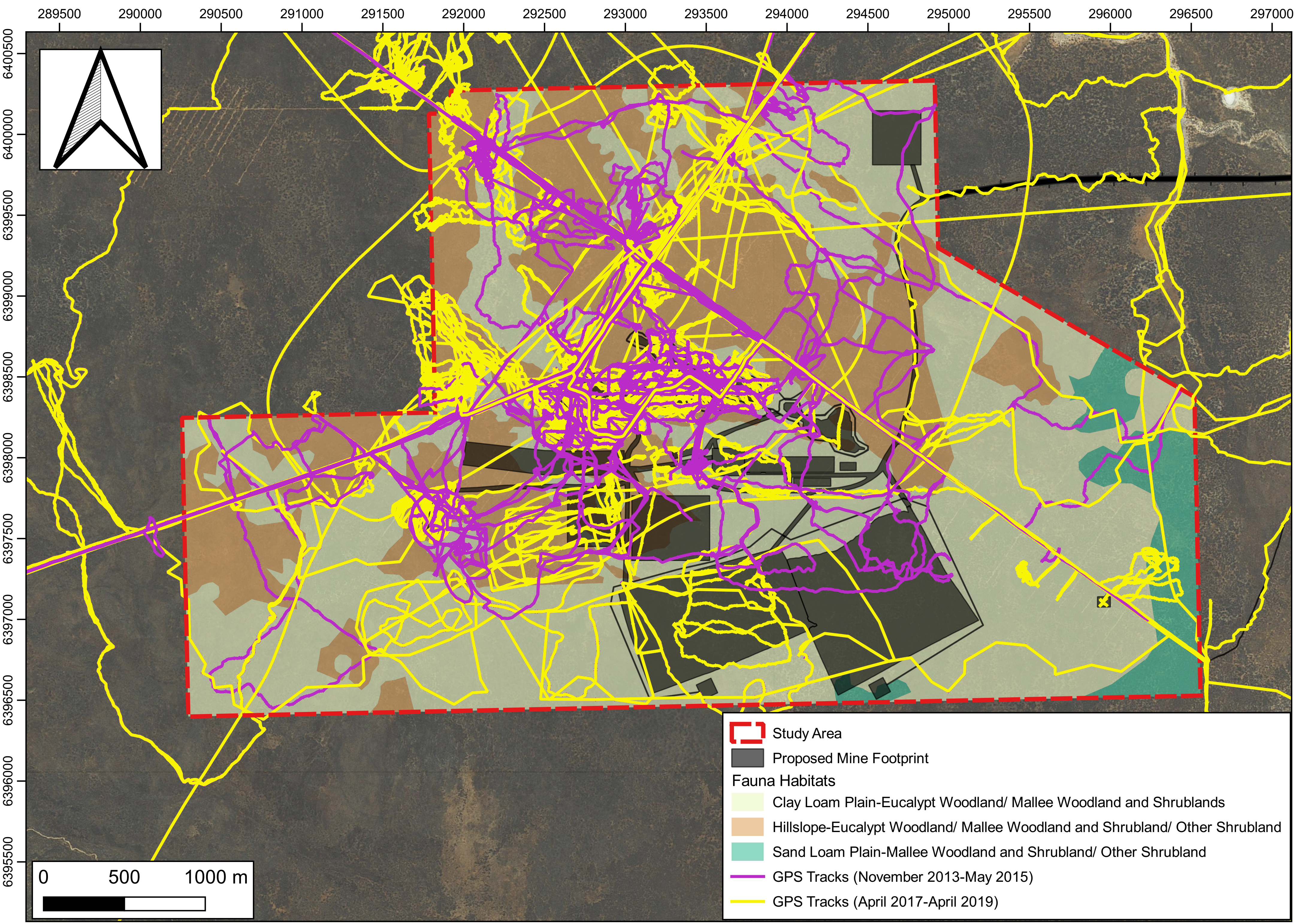


Figure 15: GPS tracks of targeted flora surveys

Soil Survey

Soil investigations were carried out in autumn and winter 2019. The soils, landform type and vegetation were described at 74 sites that were located within and adjacent to the populations of *Eucalyptus rhomboidea*, *Stenanthemum bremerense* and *M. aquilonaris* (Western Horticultural Consulting, 2019).

The GPS coordinates from the Botanica vegetation survey (2020c) were used to locate populations of the three species. A subset of these coordinates was selected for conducting the soil descriptions. Sites were chosen to sample the full range of soils present across all populations and landscape types.

A spade, pick and hand auger were used to excavate the soil (rather than a backhoe) to prevent damage to the vegetation.

Soil parameters included the depth of each soil horizon, soil texture, soil structure and colour, percentage of coarse fragments, field pH and electrical conductivity (EC) to describe each site. The soil profiles were described using the terminology of McDonald et al (1990). Soil colours were described according to standard Munsell colour chart notation. Estimates of plant available water of representative sites were calculated based on soil texture, percentage of coarse fragments and estimated rooting depth.

A total of 81 soil samples of the different soil horizons from 38 sites that represented the range of soil groups encountered in the soil survey were sent to the laboratory for physical and chemical analysis.

<u>Mapping areas of 'Shallow gravel over indurated mottled zone' soils on which the populations of *M. aquilonaris* occur</u>

East-west lines at 30 m intervals were drawn on aerial photographs over areas within and adjacent to the *M. aquilonaris* sub-populations. Initially the soil surveyor walked along these transects digging holes until the boundary of the 'Shallow gravel over indurated mottled zone' soil was identified. It was found that it was quicker and of similar accuracy for the soil surveyor to map the boundary on the 'Shallow gravel over indurated mottled zone' soil by using the presence of outcrops of mottled zone (limonite), so this approach was subsequently used instead. Way points were entered into the GPS at distances of approximately 20 m as the surveyor walked around the areas of 'Shallow gravel over indurated mottled zone' soils. The boundaries were checked against the soil profile descriptions, and by digging observation sites to confirm the soil type.

<u>Mapping of other areas of 'Shallow gravel over indurated mottled zone' in and adjacent to the tenement area on which no *M. aquilonaris* has been found</u>

Access to much of Audalia's mining tenement is limited due to a lack of tracks and the long distances that have to be covered by walking through bushland. There are four roads that radiate from the camp (SE road, SW road, NE road and NW road). The soil surveyors searched on foot for approximately 250 m on either side of these roads looking for outcrops of limonite that indicate the presence of the 'Shallow gravel over indurated mottled zone' soil. When areas of 'Shallow gravel over indurated mottled zone' soils were found the soil surveyors used a GPS to mark way points around the soil boundary.

Because of difficulties with access, only a small percentage of the area in and around the tenement was searched for the presence of the 'Shallow gravel over indurated mottled zone' soil.

Figure 16 shows the location of the soil survey points.

***M. aquilonaris* Genetic Studies**

An assessment of genetic diversity in *M. aquilonaris* sub-populations was undertaken in two stages by DBCA in 2019 in order to provide information on the population genetic diversity, structure and connectivity of *M. aquilonaris.*

The first stage assessed the genetic diversity present in each of the five sub-populations present at the time (no individuals were found at the sixth sub-population), the spatial genetic structure present among the sub-populations, and assessment of connectivity and gene flow of the sub-populations.

Genetic diversity and structure research were accomplished by sampling 30 individuals from each of the five sub-populations and undertaking genetic assessment using a reduced representation genomic sequencing approach. Several population diversity parameters were measured for each sub-population as well as overall genetic structure and differentiation. The contribution of each sub-population to the total maximal gene diversity was also evaluated. Connectivity assessment was accomplished by undertaking paternity analysis of seed collected from ten mother plants in sub-population 1b to determine the source of the pollen contribution to the seed by identifying whether the pollen is local, from within the sub-population, or from another sub-population (DBCA, 2019). This work required germination of seed into seedlings to provide sufficient material for genetic analysis.

***M. aquilonaris* Sub-Population Demographic Monitoring**

A programme of twice-yearly demographic monitoring was established in spring (September and November) 2018. Further demographic monitoring of *M. aquilonaris* sub-populations was also conducted subsequently in autumn (May) 2019 and spring (October) 2019. 27 monitoring quadrats (10 m x 10 m) were established within the *M. aquilonaris* sub-populations. The following parameters were monitored at each quadrat (Botanica, 2020a):

- Number of:
  - Mature, juvenile and dead plants;
  - Seedlings;
  - Sprouting, flowering and fruiting plants;
  - Fruits and flowers per plant
- Height / width of plants; and
- Dominant species in quadrat.

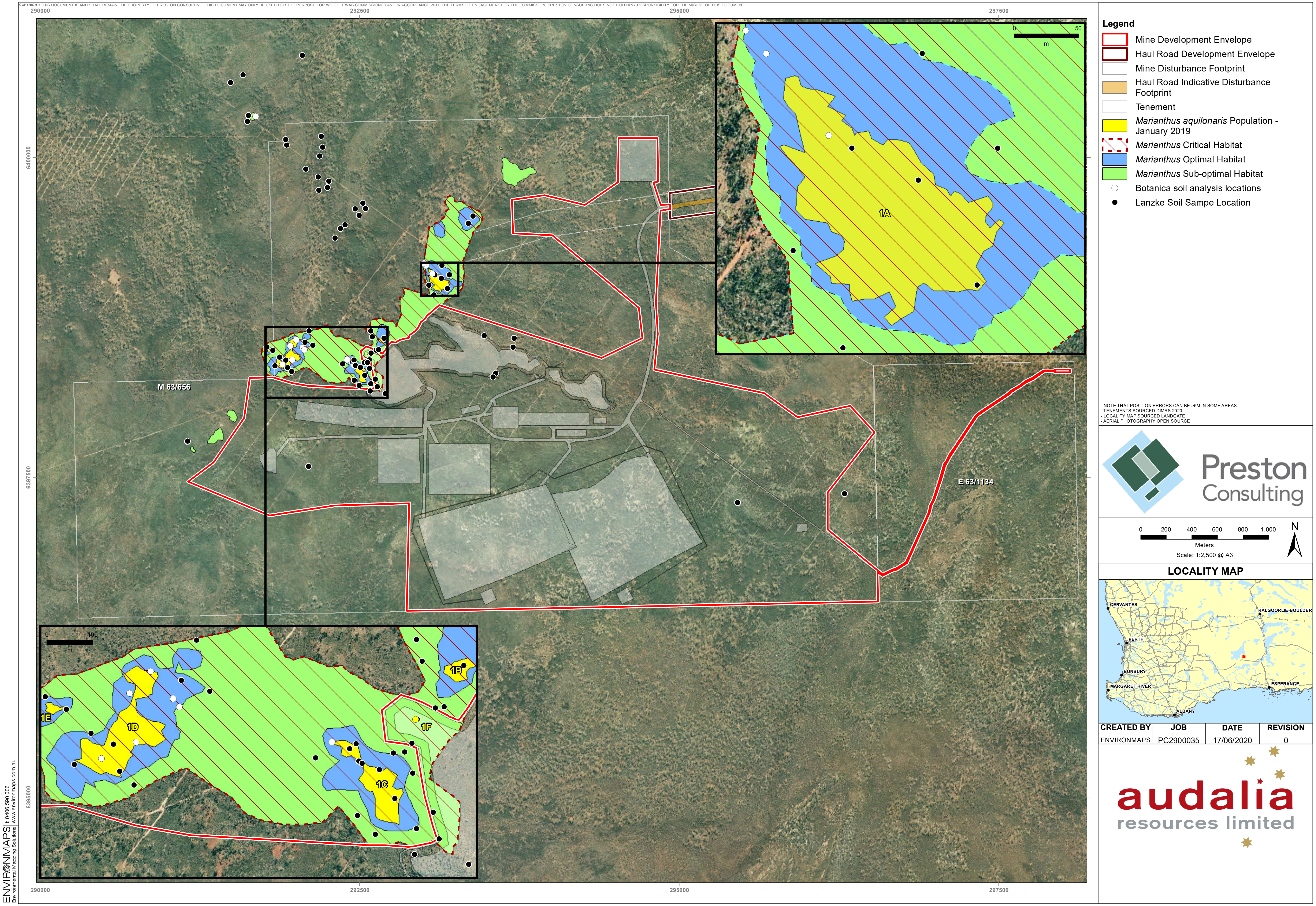


Figure 16: Extent of *M. aquilonaris* habitat soil surveys

***M. aquilonaris* Landform Monitoring**

Landform monitoring was conducted by Botanica (2019). The location of the landform monitoring transect was determined based on the following:

- The presence of suitable habitat / vegetation for *M. aquilonaris* identified during flora and vegetation surveys (Regrowth mid open mallee woodland *Eucalyptus livida* over mid open shrubland of *Hakea pendens* and open low shrubland of *Goodia medicaginea* on hillslope);
- The presence / absence of *M. aquilonaris* to ensure at least one transect was established within occupied area of each sub-population (excluding sub-population 1f which comprises of a single plant that has not been located by Botanica) and at least one transect was established within un-occupied area for each sub-population to allow for comparison of occupied and un-occupied habitat for each sub-population; and
- Elevation-to ensure at least one transect was located in the upper slope and lower slope of each *M. aquilonaris* sub-population;

Fourteen monitoring transects (100 m length) were established extending down the length of the hillslope:

- Six transects outside of the *M. aquilonaris* sub-populations (NMT1-6); and
- Eight transects within the *M. aquilonaris* sub-populations (Pop 1a - Pop 1e).

A 3 m x 3 m quadrat was established at 25 m intervals along each landform transect (Figure 17). The location of each transect was recorded using a handheld GPS and the ends of the transect were marked with metal fence droppers. The following parameters were measured within each quadrat:

- Landform Properties:
  - Morphological Type;
  - Landform Type;
  - Substrate type;
  - Elevation;
  - Aspect;
  - Loose rocks or gravel: % and size;
  - % bedrock;
  - Surface soil depth;
  - Surface resistance (LFA classification);
  - Local slope (degrees);
- Biological Properties:
  - Number of *M. aquilonaris*;
  - Condition rating of *M. aquilonaris*;
  - Dominant species per each stratum;
  - % cover per each stratum;
  - Full sun/part sun/shade;
  - % cover of bare ground; and
  - % cover of plant litter.

Descriptive variables related to landform properties such as morphological type, landform type, substrate type and loose rocks or gravel size were assessed using standard techniques described by McDonald et al. (1990).

Elevation was measured using hand held GPS, surface soil depth was measured using a ruler (mm) and the local slope was measured using a level. Percentage cover of each stratum was classified in accordance with the NVIS foliage cover categories (DotEE, 2018). Percentage cover of bedrock and bare ground/ plant litter were estimated based on coverage within the 3 m x 3 m quadrat.

Principal Components Analysis and factor analysis was conducted using the statistical programme PAST3 were conducted to determine the environmental variables which accounted for most of the variance in the set of observed variables. The analysis was conducted for all quadrats (70 quadrats; 37 *M. aquilonaris* absent and 33 *M. aquilonaris* present). Patterns of dissimilarity among environmental variables (those identified in Principal Components Analysis to account for most the variance) between *M. aquilonaris* present and *M. aquilonaris* absent sites were assessed using non-metric multi-dimensional scaling (nMDS). The significance of dissimilarities in the composition of those variables between *M. aquilonaris* present and *M. aquilonaris* absent sites was tested using Analysis of Similarities (ANOSIM).

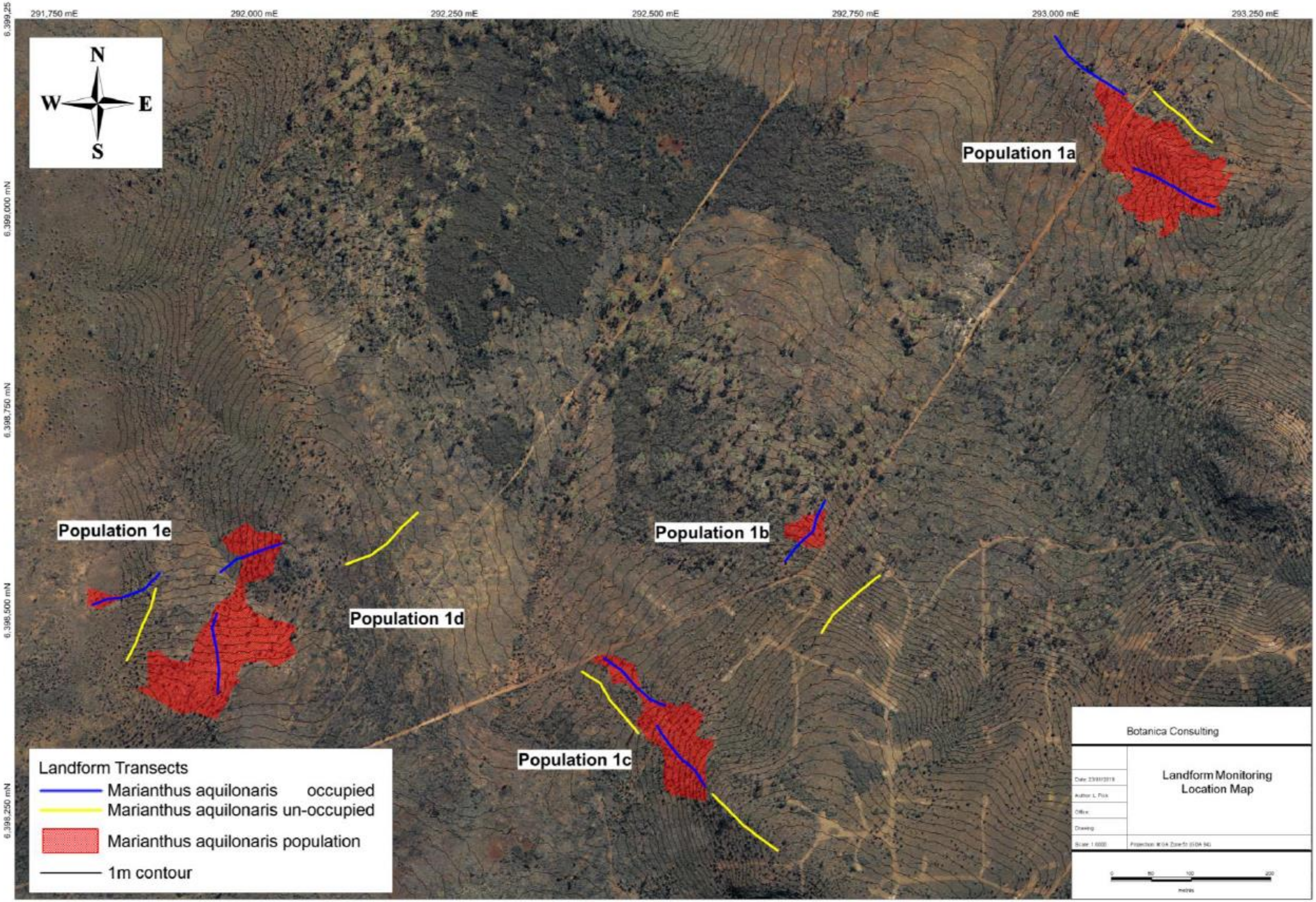


Figure 17: Location of landform monitoring transects

Microhydrology and Microclimate (M. aquilonaris)

The following study was undertaken to characterise the surface water hydrology of the Mine DE with a focus on *M. aquilonaris* habitat:

- Lake Medcalf Hydrogeological and Hydrological Study: Characterisation of *Marianthus aquilonaris* Habitat (Groundwater Resource Management (GRM; 2020c).

This work included a data collation review, site visit and characterisation of the hydrology of the area supporting *M. aquilonaris* communities.

<u>Data review</u>

The data review involved sourcing available data and undertaking a preliminary review of local and catchment conditions; including the following information:

- 1 m contour data and high resolution aerial imagery across the site;
- Proposed indicative site layout across the mine site;
- Mapping of *M. aquilonaris* sub-populations;
- Site weather station data (incomplete record for the period 4 April 2014 - 12 June 2018);
- Regional topographic and satellite imagery data, supplied by Geoscience Australia;
- Regional weather and design rainfall data, supplied by BoM; and
- Other relevant reports (as referenced in GRM, 2020c).

<u>Site Visit</u>

A site visit was undertaken on 29 - 30 November 2018 by R. Connolly (Principal Hydrologist). During the visit the landscape and drainage through the areas of *M. aquilonaris* habitat were inspected. Drainage lines crossing the haul road alignment were inspected.

Landscape and drainage lines were inspected during a site visit. This was followed by data analysis and modelling of the microclimate including meteorological conditions and surface water drainage.

<u>Characterisation of *M. aquilonaris* Sub-population Hydrology and Microclimate</u>

An assessment of the hydrogeological conditions associated with *M. aquilonaris* sub-populations was undertaken in September 2019, as part of the water supply investigations for the Proposal.

The microclimate of the communities was described using a combination of data analysis and modelling. This included:

- Characterisation of the climate of the area, using site and regional weather records;
- Identifying catchments and topographic, terrain and soil features for the area;
- Modelling the water balance of the sub-populations, including identifying major flow pathways and sources of water that may influence the presence of sub-populations; and
- Interpreting possible relationships relevant to the presence of *M. aquilonaris* sub-populations.

Stations recording long term weather in the area are sparse, so it was difficult to determine reliable averages at the site. The site weather station data is also not a continuous record. Accordingly, the data used for analysis of site climate and for input into the water balance model data were derived from a number of sources and should be considered to be indicative but sufficient to characterise the environment.

Daily weather data from the site station and generated data using the BoM's Data Drill (Queensland Government, 2018) were used. The site rainfall data covered the period 2014 - 2018 with a 0.5 or 1 h time step but is not complete. The Data Drill data for a number of locations was tested and it was found that data generated at the location of the BoM Salmon Gums Station, located some 90 km to the southeast of the mine site, gave the best overall representation of weather at the site compared with other BoM stations in the area. Design rainfall was also derived for the site using the BoM's online data tool. These data were used in the assessment of site climate and in the water balance modelling.

Surface water catchments and drainage lines through the sub-populations were defined using 1 m contour data sourced from Audalia.

A catchment water balance model was setup using the MIKE SHE software (DHI, 2018) which is an advanced, flexible framework for modelling major processes in the hydrologic cycle. It includes process models for evapotranspiration, overland flow, unsaturated flow, groundwater flow, channel flow and their interactions. Each of these processes can be represented at different levels of spatial distribution and complexity, according to the goals of the modelling study, the availability of field data and the modeller's choices.

The MIKE SHE model was used to help assess the water balance for the catchments through the *M. aquilonaris* sub-populations and for rock holes in the area. The water balance is predicted for the root zone for the period 2014 - 2017, which is the period of site rainfall monitoring.

The model was parameterised using the available data. Site rainfall data and daily Data Drill rainfall and evaporation data were used in the model for different model scenarios. Topography was represented in the model as a rectangular grid (5 m x 5 m cell), derived from the contour data. Soil information was based on observations made during the site visit and using information in Western Horticultural Consulting (2019). No mapping of soils across the site, other than for the 'Shallow gravel over indurated mottled zone' soil group, was available. The distribution of other soils was assumed. Based on site observations at the areas occupied by *M. aquilonaris* and the soil type 'Shallow gravel over indurated mottled zone', the modelling assumed hard rock occurs below the soil profile.

Two scenarios were modelled:

1. Rainfall events, using the site data; and
2. Catchment and rock hole water balance, 2014 - 2017, using daily weather data.

The catchment and rock hole model was set up with minimal data and run for a short period (four years), so the results should be considered indicative but sufficient to characterise the microhydrological environment where *M. aquilonaris* grows.

Two rock holes (east and west) were included in the water balance model. Rock holes were represented by lowering the elevation of a single cell at each site by 0.5 m below ground surface. This gave an effective depth of 0.26 m for the western and 0.12 m for the eastern rock hole. This is an approximation, as the model grid size (5 m x 5 m) is larger than the size of the actual rock holes and shape of the rock holes is not represented in detail. The model represents overland flow into the rock hole and evaporation and seepage. There may be other losses (such as animal use) and local factors (such as variable runoff patterns at the micro scale or variable vegetation use) that are not included in the model and could affect the actual water balance of the rock holes.

Nevertheless, the model helps characterise the rock hole water balance, including the contributing catchment and likely rate and mechanisms of loss of water ponded in the holes.

***M. aquilonaris* Geomorphology**

A baseline geomorphology study was undertaken by World Technical Services Group, (2019; Appendix 3.1). This study was in relation to the *M. aquilonaris* sub-populations identified adjacent to the Mine DE.

The study reviewed characteristics related to the *M. aquilonaris* and the Mine DE to assess the sub-populations of *M. aquilonaris* and the geology that they grow in, including records of rainfall, evaporation, bushfires, ecological assessments, regional geology and topography.

Germination

Botanica was commissioned by Audalia to conduct a small germination trial for *M. aquilonaris.* The purpose of the trial was to determine germination success of this taxon outside of its natural habitat. Prior to the germination trial, seeds and soils from known *M. aquilonaris* sub-populations were collected (under permit to take Declared Rare Flora licence 115-1415). Germination trials commenced on 8 August 2015 using two separate germination mediums; Agar and Soil.

Smoke water and germination powder were used in an attempt to imitate germination of the *M. aquilonaris* seeds in agar germination trials with no success. Forty two trial plots of *M. aquilonaris* seeds were planted in soils sourced locally and from *M. aquilonaris* sub-populations. Four germinants were recorded, two of which had features consistent with the taxonomy of *M. aquilonaris.* None of the germinants survived to the juvenile stage.

Collections were weighed (initial collection weight) then dried under standard conditions of 15% relative humidity at 15°C for a minimum of two weeks before quality assessments were undertaken.

Germination was also undertaken by DBCA for the genetic study (DBCA, 2019). The seed collections of *M. aqulionaris* from ten mother plants in sub-population 1b were cleaned then counted. For germination, 45 seeds from each mother plant had the seed coat nicked with a scalpel blade. Seeds were then soaked in a 10% solution of PPM (Plant Preservative Material supplier, (Plant Cell Technology)) for 15 min before being placed onto agar containing 100 mg/L Gibberellic Acid (GA3). Gibberellic Acid (filter sterilised) was added to autoclaved water agar that had cooled to a temperature of 60°C. Plates were incubated at 15°C with light/dark cycles of 12 hours.

5.3.2 Regional Biophysical Environment

Regional Environment

The Proposal lies within the Coolgardie Botanical District of the South-West Province of WA. The Coolgardie Botanical District consists of predominantly mulga low woodland on plains and reduces to scrub on hills (Beard, 1990).

Based on the Interim Biogeographic Regionalisation of Australia (IBRA), Version 7 (DotEE, 2012), the survey area is located within the Coolgardie Bioregion of WA (Figure 3). The Coolgardie Bioregion is further divided into three subregions; Mardabilla, Southern Cross and Eastern

Goldfield subregion with the survey area located within the Southern Cross (COO02) and Eastern Goldfield (COO03) subregion (Figure 18). The Proposal is located approximately 5 km north of the Mallee Bioregion, which is divided into two subregions; Eastern Mallee (MAL01) and Western Mallee (MAL02) as shown in Figure 18.

The Coolgardie Bioregion is within the Yilgarn Craton. The climate is arid to semi-arid warm Mediterranean with 250 - 300mm of mainly winter rainfall. It comprises diverse woodlands, rich in endemic eucalypts, which occur on low greenstone hills, alluvial soils on the valley floors, around the saline playas of the region's occluded drainage system and on broad plains of calcareous earths. Granite basement outcrops occur at mid-level in the landscape, supporting swards of 'granite grass', Acacia shrublands and York Gum. The playa lakes support dwarf shrublands of samphire. Sand lunettes are associated with playas along the broad valley floors, and sand sheets surround the granite outcrops. Upper levels in the landscape are the eroded remnants of a Tertiary lateritic duricrust, with yellow (in the Southern Cross subregion) or red (in the Eastern Goldfield subregion) sandplains, gravel plains and laterite breakaways. These support scrubs and mallees. In the west, these scrubs are rich in endemic Proteaceae; in the east, they are rich in endemic Acacias (McKenzie, May and McKenna, 2002).

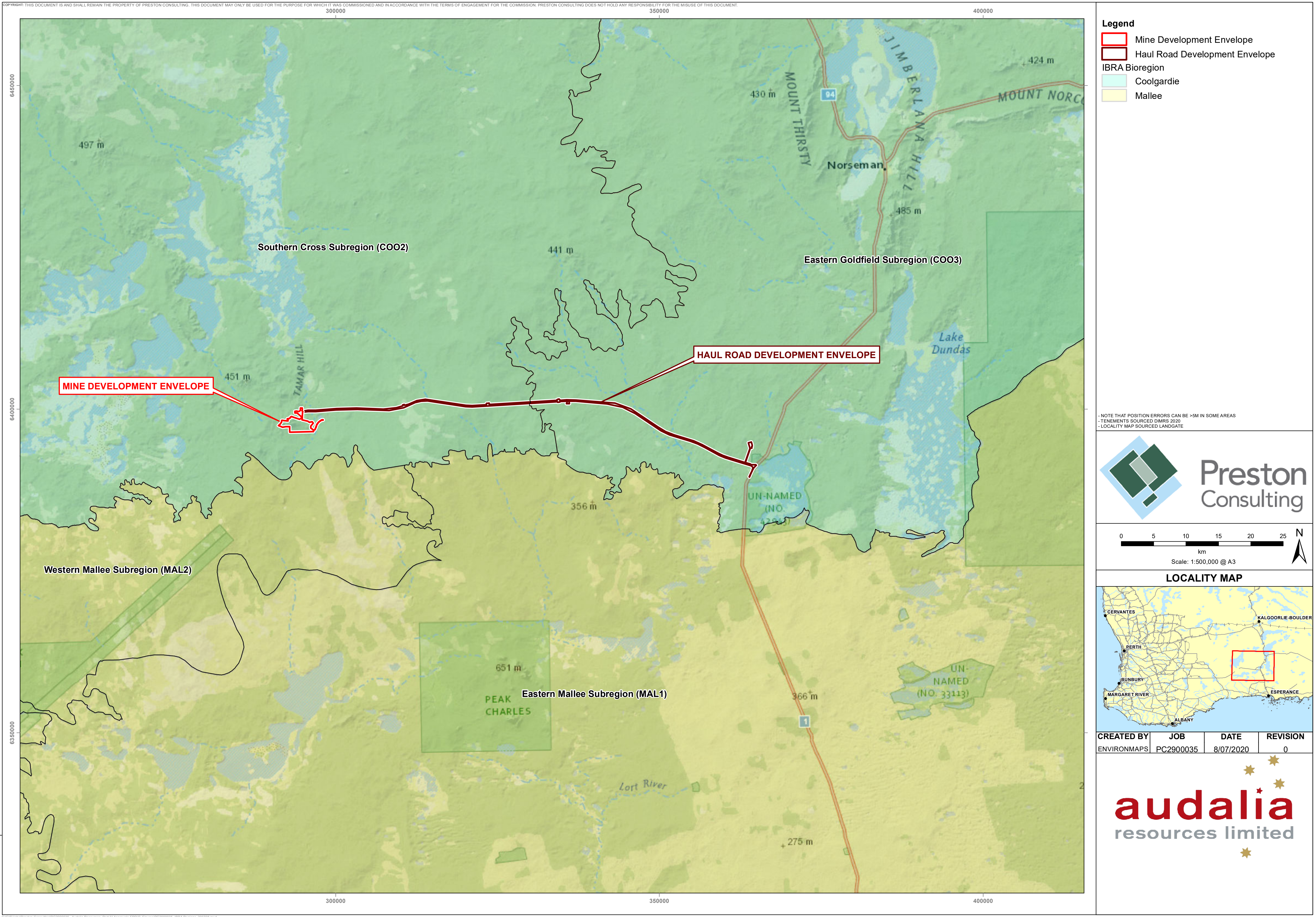
The Mallee Bioregion occurs within the south-eastern part of Yilgarn Craton and is gently undulating, with partially occluded drainage. The climate is Mediterranean to semi-arid, with winter rainfall of between 250 – 500 mm. This region includes mallee communities, samphires around small salt lakes and Eucalyptus woodlands occur mainly on fine-textured soils, with scrub-heath on sands and laterite (McKenzie et. al., 2002).

Great Western Woodlands

The Proposal lies within the Great Western Woodlands (Figure 19). The Great Western Woodlands is considered by The Wilderness Society to be of global biological and conservation importance as one of the largest and healthiest temperate woodlands on Earth, containing up to 20% of Australia's species (Wilderness Society, 2020). The region covers almost 16 million ha from the southern edge of the WA Wheatbelt to the pastoral lands of the Mulga country in the north, the inland deserts to the northeast, and the treeless Nullarbor Plain to the east.

The Great Western Woodlands provides an eastward connection between southwest forests of WA and inland deserts (known as the Gondwana Link) as well as linking a north-west passage of largely intact vegetation through to Shark Bay. The majority of the Great Western Woodlands is unallocated crown land (61.1%) with other interests including pastoral leases (20.4%), conservation reserves (15.4%), unallocated crown land ex pastoral managed by the DBCA (2%) and private land (approximately 1%) (Watson et. al., 2008).

No specific management strategy applies to the Great Western Woodlands, the approach to conservation requires coordination across a range of land tenures. The central component of this approach is to identify and conserve key large-scale, long term ecological processes that drive connectivity between ecosystems and species (DEC, 2011). The Great Western Woodlands currently includes towns, highways, roads, railways, private property, Crown Reserves, agricultural activities (largely pastoralism) and mining tenements.



CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900035	8/07/2020	0

audalia resources limited

ENVIRONMAPS Environmental Mapping Solutions t 0406 590 006 www.environmaps.com.au

Figure 18: IBRA Regions

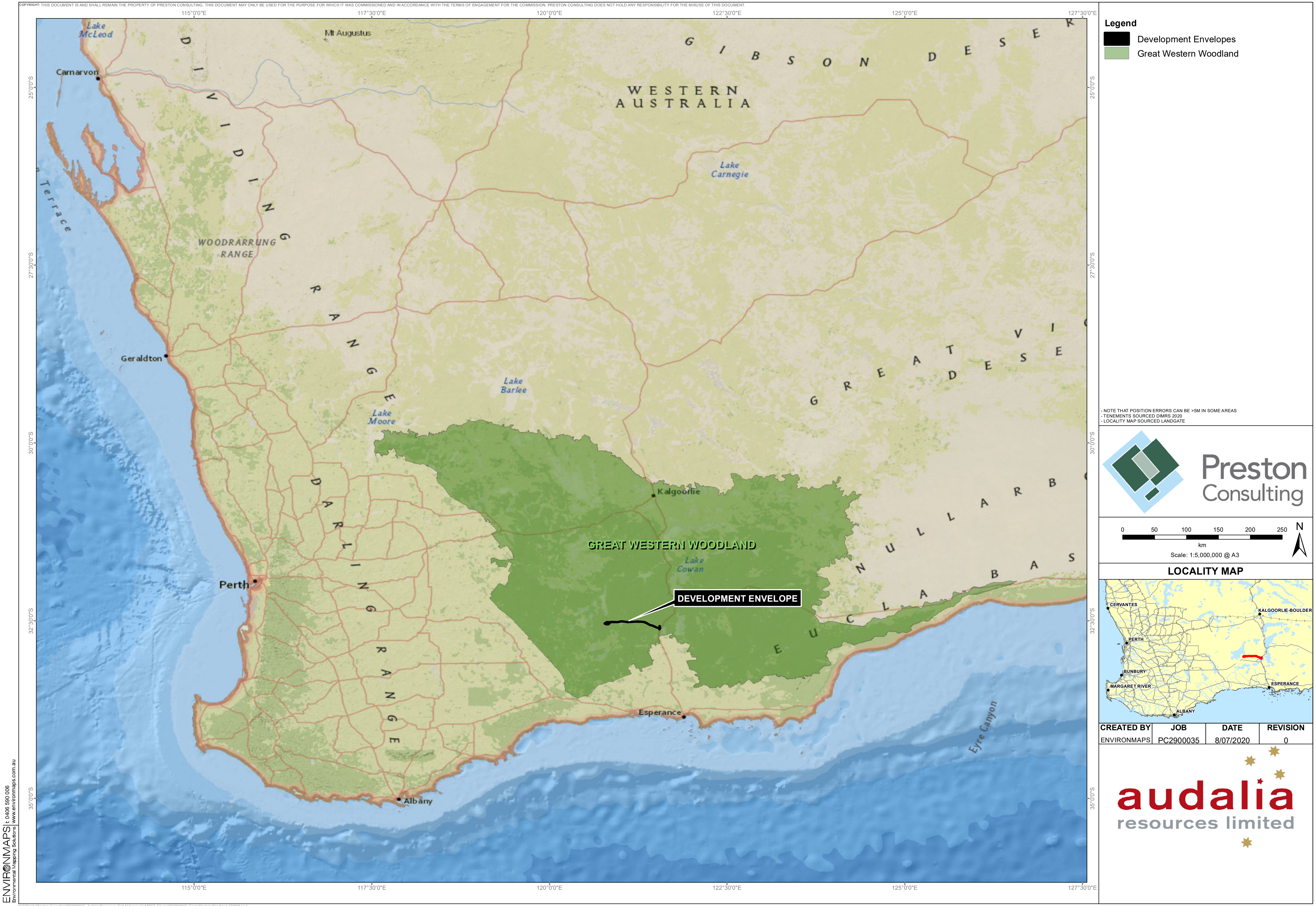


Figure 19: Location of Development Envelopes within the Great Western Woodlands

Soils and Landscape Systems

The Southern Cross subregion (COO02) lies on the Yilgarn Craton's 'Southern Cross Terrains'. The relief is subdued and comprises of gently undulating uplands dissected by broad valleys with bands of low greenstone hills. The underlying geology is of granite strata interrupted by parallel intrusions of Archaean Greenstone. Calcareous earths are the dominant soil community and cover much of the plains and greenstone areas. A series of large playa lakes in the western half are the remnants of an ancient major drainage line (Cowan, 2001). Beard (1990) describes the topography of the region as gently undulating with occasional range of low hills and sandplains in the western area and some large playa lakes. The dominant soil type is calcareous earth.

The Eastern Goldfield subregion (COO03) lies on the Yilgarn Craton's 'Eastern Goldfields Terrains'. The relief is subdued and comprises of gently undulating plains interrupted in the west with low hills and ridges of Archaean greenstones and in the east by a horst of Proterozoic basic granulite. The underlying geology is of gneisses and granites eroded into a flat plane covered with tertiary soils and with scattered exposures of bedrock. Calcareous earths are the dominant soil group and cover much of the plains and greenstone areas. A series of large playa lakes in the western half are the remnants of an ancient major drainage line (Cowan, 2001).

Based on geographic information provided by DPIRD, the Proposal is located within the Salmon Gums Mallee Zone (246) of the Stirling Province (24) and the Norseman Zone (266) of the Kalgoorlie Province (26).

The Salmon Gums Mallee Zone is characterised by flat to undulating plains (with some salt lakes) on deeply weathered mantle and alluvium over Bremer Basin sediments on granite and gneiss of the Yilgarn Craton and Albany-Fraser Orogen. Soils include calcareous loamy earths and alkaline grey shallow sandy duplexes with salt lake soils and some alkaline grey shallow loamy duplexes and pale deep sands. Vegetation includes merrit-coral gum-Salmon gum-red mallee woodlands with mallee scrub and some mallee heath. This zone is located in the South Coast district between Pyramid Lake, Scaddan, Norseman and Mt Ragged (Tille, 2006).

The Norseman Zone is characterised by undulating plains and uplands (with some sandplains and salt lakes) on granitic rocks of the Yilgarn Craton. Soils include calcareous loamy earths, yellow sandy and loamy earths, red loamy earths, red deep sands and salt lake soils. Vegetation includes Salmon gum-redwood-merrit-red mallee-gimlet woodland with Acacia-Casuarina thickets (and some mulga shrublands and spinifex grasslands). This zone is located in the southern Goldfields between Koolyanobbing, Menzies, Zanthus (Trans-Australian Railway), Norseman and Lake Hope (Tille, 2006).

These zones are further divided into soil landscape systems, with the soil landscape systems of the Proposal listed in Table 13 and shown in Figure 20 (ASRIS, 2014). Note that some artificial boundaries are displayed due to mapping limits).

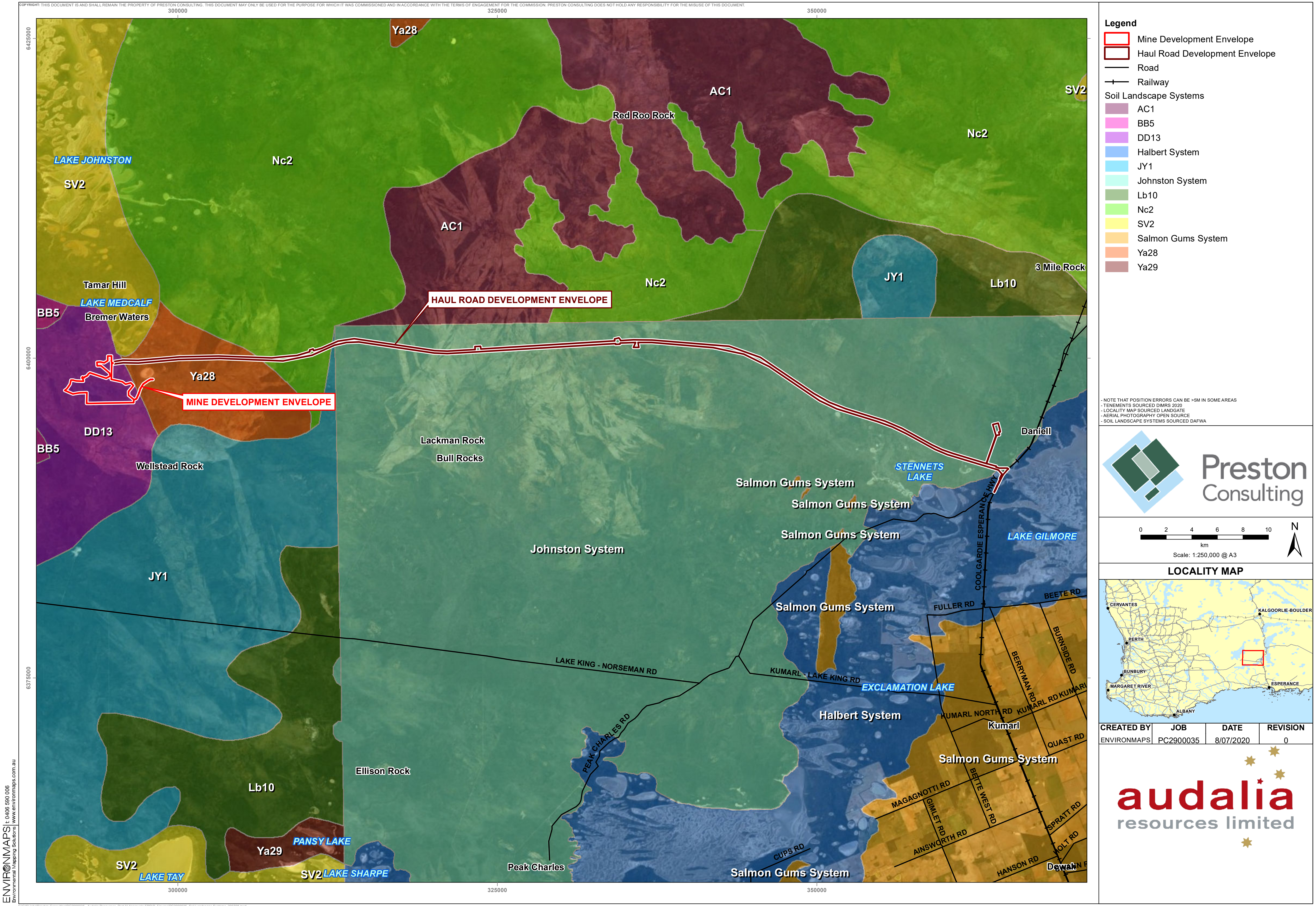


Figure 20: Land Systems

Table 13: Landscape systems of the Proposal

Zone	Landscape System / Mapping Unit	Description
Salmon Gums Mallee Zone (246)	Herbert System	Level to gently undulating plain with numerous salt lakes within a paleo valley on Tertiary marine sediments (Plantagenet and Werrilup formations). Soils are alkaline grey shallow sandy duplex soils and salt lake soils
	Johnston System	Gently undulating inland plain with occasional rises on Archaean granite deeply weathered
	JY1	Undulating land with small valleys and flats
Norseman Zone (266)	DD13	Gently undulating plains with some gilgai areas, occasionally broken by stony ridges and hills
	Nc2	Gently undulating plains with some gilgai areas, and irregularly broken by small remnants of sand plain, unit AC1, and granitic bosses and tors
	SV2	Saline valleys with some dunes including barchan forms-salt lake channels, mostly devoid of true soils, and their fringing areas
	Ya28	Sandy plains with some clay pans and small salt lakes, dunes, and lunettes

Remnant Vegetation - Vegetation Associations

The Pre-European Vegetation extent GIS file (DPIRD, 2018) indicates that the survey area is located within Pre-European Beard vegetation associations of the Binneringe, Bremer Range, Cave Hill and Dundas systems (Figure 21). The extent of these vegetation associations as specified in the *2018 Statewide Vegetation Statistics* (DBCA, 2018a) is provided in Table 14.

Areas retaining less than 30% of their pre-European vegetation extent generally experience exponentially accelerated species loss, while areas with less than 10% are considered 'endangered' (Botanica, 2020c). All of the vegetation types present in the areas intersected by the survey area are estimated to have more than 97% their estimated pre-European extent remaining.

Table 14: Pre-European vegetation associations within the Proposal

IBRA Subregion	Vegetation Association and description	Pre-European extent (ha)	Current extent (ha)	% remaining	% of current extent within DBCA managed lands
Southern Cross (COO2)	**Bremer Range 491***** Medium woodland; morrel & Dundas Blackbutt (*E. dundasii)*	67, 120	67, 021	99.85	0
	Cave Hill 125* Bare areas; salt lakes	46, 346	46,345	100	0
	Cave Hill 128* Bare areas: rock outcrops	35,277	35,265	99.97	0.50
	Cave Hill 522*** Medium Woodland; redwood (*Eucalyptus transcontinentalis)* & merit (*E. flocktoniae*)	160,658	160,643	99.99	0.18
	Cave Hill 936** Medium Woodland; salmon gum	157,638	157,638	100	0
	Cave Hill 1148* Shrublands; scrub-heath in the Coolgardie region	21,463	21,463	100	0

IBRA Subregion	Vegetation Association and description	Pre-European extent (ha)	Current extent (ha)	% remaining	% of current extent within DBCA managed lands
	Cave Hill 1413* Shrublands; Acacia, Casuarina & Melaleuca thicket	81,471	81,471	100	0.10
Eastern Goldfields (COO3)	**Binneringe 522***** Medium woodland; redwood (*Eucalyptus transcontinentalis*) & merrit (*E. flocktoniae*	166,611	166,394	99.87	0.34
	Cave Hill 522*** Medium woodland; redwood (*Eucalyptus transcontinentalis*) & merrit (*E. flocktoniae*)	14,855	14,855	100	0
	Cave Hill 1413* Shrublands; Acacia, Casuarina & Melaleuca thicket	6,463	6,463	100	0
	Dundas 125* Bare areas; salt lakes	56,750	56,750	100	16.19
	Dundas 128* Bare areas; rock outcrops	3,516	3,515	99.99	0
	Dundas 486 Mosaic: Medium woodland; salmon gum & red mallee / Shrublands; mallee scrub *Eucalyptus eremophila*	22,349	22,349	100.00	0
	Dundas 551* Shrublands; *Allocasuarina campestris* thicket	844	844	100.00	0
	Dundas 3106 Medium woodland; salmon gum & Dundas blackbutt	52,659	51,601	97.99	7.81

**Low Reservation Priority according to the IUCN*
***Medium Reservation Priority according the IUCN*
****High Reservation Priority according the IUCN*

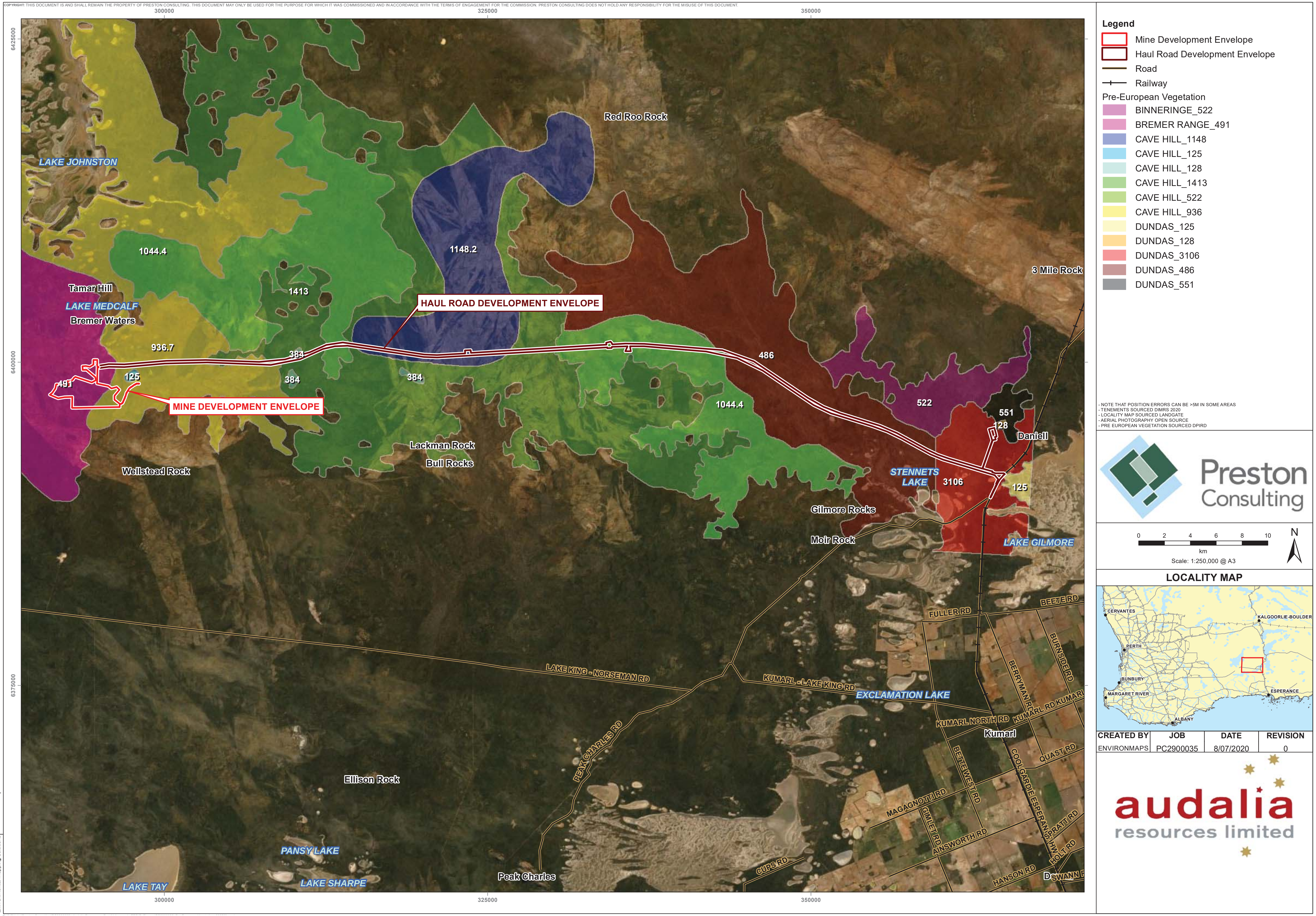


Figure 21: Pre-European vegetation associations within the development envelopes

Climate

The climate of the Coolgardie Bioregion is characterised as arid to semi-arid warm Mediterranean with 250 - 300mm of mainly winter rainfall (McKenzie *et. al.*, 2002). Mean climate data for the Norseman aero weather station (#12009) obtained from BoM is provided in Figure 22 (BoM, 2020). Average monthly rainfall across the entire survey period (2014 - 2019) is shown in Figure 23 and shows a relatively even spread of rainfall throughout the year on an average basis (i.e. significant rainfall may fall in any month, but there is a prevalence for higher monthly rainfall totals over the warmer months).

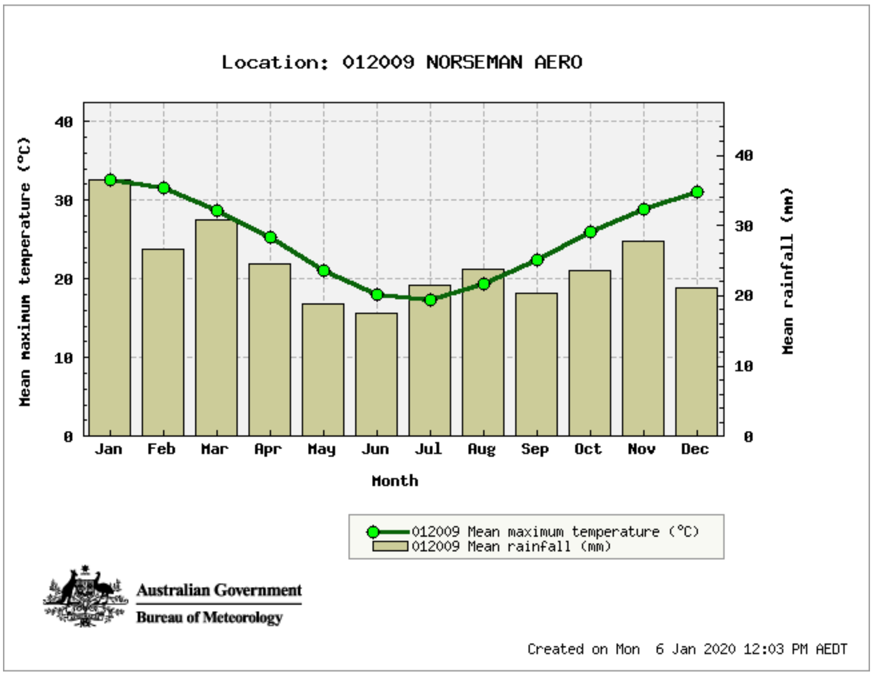


Figure 22: Mean monthly rainfall and maximum temperature (1999 - 2019) for the Norseman Aero weather station

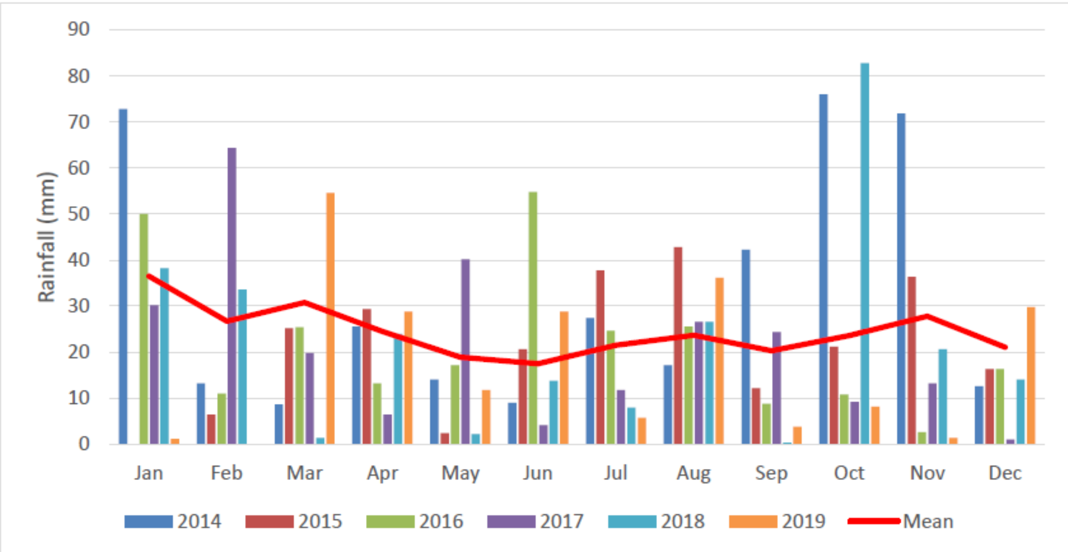


Figure 23: Monthly rainfall and mean monthly rainfall (January 2014 - December 2019) for the Norseman Aero weather station

Land Use

The dominant land uses of the Southern Cross subregion are; native pastures (17%), Conservation Reserves (11.53%), UCL & Crown Reserves (66.74%) and Cultivation – Dry Land agriculture (2.27%) (Cowan, 2001). The dominant land uses of the Eastern Goldfields subregion are UCL and Crown reserves, Grazing-Native pastures-leasehold (37.8%), freehold (7.15%), conservation, and Mining leases (Cowan, 2001). The DEs lie entirely on UCL.

The Mine DE and 167 ha of the Haul Road DE occurs within the proposed Bremer Range Nature Reserve. The proposed Bremer Range Nature Reserve covers a total area of 50,920 ha, centred on the Bremer Range. In 1992 it was proposed that the Bremer Range be managed by DBCA as a Nature Reserve in the DBCA South Coast Region Regional Management Plan, however, to date this proposed reserve has not yet been approved, primarily due to the presence of mineralisation. It is also not listed under the EPA Red Book recommendations for Conservation Reserves 1975-1993.

5.3.3 Field Survey Results – Significant Flora Overview

According to the EPA Environmental Factor Guideline for Flora and Vegetation (EPA, 2016c) significant flora includes:

- Flora being identified as Threatened or Priority species;
- Locally endemic flora or flora associated with a restricted habitat type (e.g. surface water or GDEs);
- New species or anomalous features that indicate a potential new species;
- Flora representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; and
- Flora with relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

One Threatened Flora taxon pursuant to the BC Act was identified within the survey area; *M. aquilonaris*. This taxon is not listed as Threatened under the EPBC Act. A map showing the *M. aquilonaris* sub-populations is provided in Figure 25. Ten Priority Flora taxa as listed by DBCA were also identified within the survey area:

1. *Acacia hystrix* subsp. *continua* (P1);
2. *Acacia mutabilis* subsp. *stipulifera* (P3);
3. *Bossiaea flexuosa* (P3);
4. *Brachyloma stenolobum* (P1);
5. *Eucalyptus pterocarpa* (P3);
6. *Eucalyptus rhomboidea* (P4);
7. *Hakea pendens* (P3);
8. *Microcybe* sp. Windy Hill (G.F. Craig 6583) (P3);
9. *Stenanthemum bremerense* (P4); and
10. *Teucrium diabolicum* (previously named *Teucrium* sp. dwarf (R. Davis 8813) (P3)). This taxon has been recently formally named as *Teucrium diabolicum*, and Audalia is currently seeking clarification as to whether it remains a Priority Flora species. For the purpose of this ERD it is assumed that it remains as a Priority 3 Flora species.

The number of individuals of each of these species recorded within the region and survey area is provided in Table 15. A map showing the locations of these flora taxa identified within the survey area is provided in Figure 24, with detailed mapping provided in Appendix 3.12.

Table 15: Significant flora recorded within survey area

Flora	Conservation Status	Regional extent (no.)	Extent in survey area (no.)	Extent in DEs (no.)
M. aquilonaris	T	14,627	14,627	0
Acacia hystrix subsp. *Continua*	P1	122	100	0
Acacia mutabilis subsp. *Stipulifera*	P3	348,452	348,311	11,215
Bossiaea flexuosa	P3	217	100	0
Brachyloma stenolobum	P1	560	500	0
Eucalyptus pterocarpa	P3	100	100	0
Eucalyptus rhomboidea	P4	15,606	5,730	1,198
Hakea pendens	P3	6,783	2,100	1,246
Microcybe sp. Windy Hill (G.F. Craig 6583)	P3	26,962	620	20
Stenanthemum bremerense	P4	40,126	30,211	3,455
Teucrium diabolicum	P3	16,153	11,200	1,450

One of the Priority Flora taxa identified; *Eucalyptus rhomboidea* (P4) is currently being nominated by DBCA for Threatened status under the BC Act. A second Priority Flora taxon; *Stenanthemum bremerense* (P4) is being considered by DBCA for nomination to Threatened status under the BC Act. A map showing the population area of *Eucalyptus rhomboidea* and *Stenanthemum bremerense* is provided in Figure 25.

Locations of all significant flora listed on the DBCA database within the survey area were searched during the surveys, however the following taxa were not identified during the surveys:

1. *Aotus* sp. Dundas (M.A. Burgman 2835); and
2. *Stylidium pulviniforme.*

The following other significant flora listed in EPA, 2016c were not recorded during the surveys:

- Locally endemic flora or flora associated with a restricted habitat type (e.g. surface water or GDEs);
- New species or anomalous features that indicate a potential new species;
- Flora representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; or
- Flora with relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

A total of eight sterile taxa were identified during the Botanica (2020c) survey (Figure 26). An assessment on the potential for each sterile taxon to be a significant taxon was conducted by Botanica (2020c) based on review of potential flora listed on the NatureMap database search, the findings of the existing survey work conducted within the Bremer Range (Gibson and Lyons, 1998), species identified during surveys conducted by Botanica and the desktop assessment on the potential for conservation significant flora to occur within the survey area. All of the sterile taxa were identified as having a low likelihood of being significant flora (Table 16).

Table 16: Assessment of sterile taxa recorded within survey area

Taxon	Coordinate/ Locality	Associated Vegetation	Likelihood of being significant flora
Allocasuarina sp. sterile	Regrowth within the Mine Survey Area – widespread (numerous record locations)	HS-MWS1, HS-MWS2, HS-OS1	Low - 4 *Allocasuarina* taxa potentially occurring within the local region/ previously recorded within the survey area, none of which are significant.
Tecticornia sp. sterile	Single sterile recorded within the Haul Road Survey Area - Located in Eucalypt Woodland/ not associated with playa / fringing vegetation.	CLP-EW1	Low – 8 *Tecticornia* taxa potentially occurring within the local region/ six identified during the survey, none of which are significant. Given this taxon was recorded within understorey vegetation of Salmon Gum woodland and not associated with playa vegetation, the likelihood of this sterile Tecticornia being significant is low.
Dillwynia sp. sterile	Single sterile recorded within the Haul Road Survey Area	SLP-MWS1	Low - 1 *Dillwynia* taxon potentially occurring within the local region, which is not significant
Acacia sp. sterile	Regrowth within the Mine Survey Area – widespread (numerous record locations)	CLP-MWS1, SLP-OS1	Low - 7 conservation significant *Acacia* possible to occur within survey area. 43 *Acacia* identified within the survey area, only one of which is conservation significant. Given the high proportion of *Acacia* identified, the likelihood of this sterile *Acacia* being significant is low
Eucalyptus sp. sterile mallee	Regrowth within the Mine Survey Area	HS-MWS3, SLP-MWS2, SLP-OS1	Low - 4 conservation significant Mallees possible to occur within survey area. 24 Mallee identified within the survey area. Given the high proportion of Mallee identified, the likelihood of this sterile Mallee being significant is low
Eucalyptus sp. sterile	Regrowth within the Mine Survey Area and Haul Road Survey Area – widespread (numerous record locations)	CLP-EW1, CLP-MWS1, CLP-MWS2, HS-EW1, HS-MWS1, HS-MWS2, HS-MWS3, HS-OS1, SLP-MWS1, SLP-MWS2, SLP-OS1	Low- 4 conservation significant trees possible to occur within the survey area. 14 Eucalypts identified within the survey area, two of which are conservation significant. Given the high proportion of Eucalypts identified and the variety of habitats the sterile Eucalypt occurred in, the likelihood of this sterile Eucalypt being significant is low
Melaleuca sp. sterile	Regrowth within the Mine Survey Area.	CLP-EW1, CLP-MWS2, HS-OS1	Low - Specimen assessed by WAHERB taxonomist - may be *M. villosisepala* but not enough flowering material.
Caladenia sp. sterile	Single sterile record within the Mine Survey Area	HS-MWS1	Low - 6 *Caladenia* taxa potentially occurring within the local region, none of which are significant

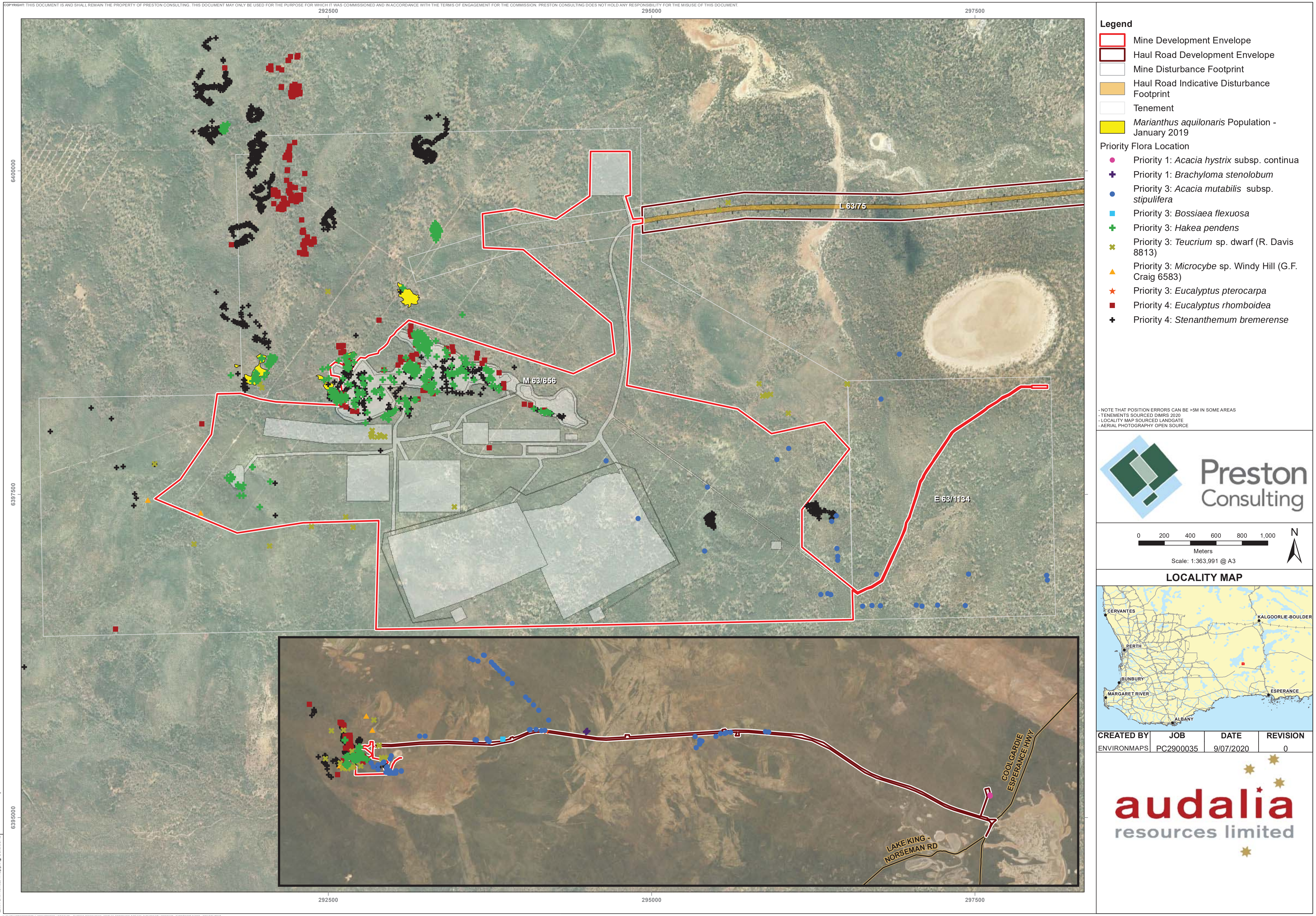


Figure 24: Significant flora recorded within the survey area

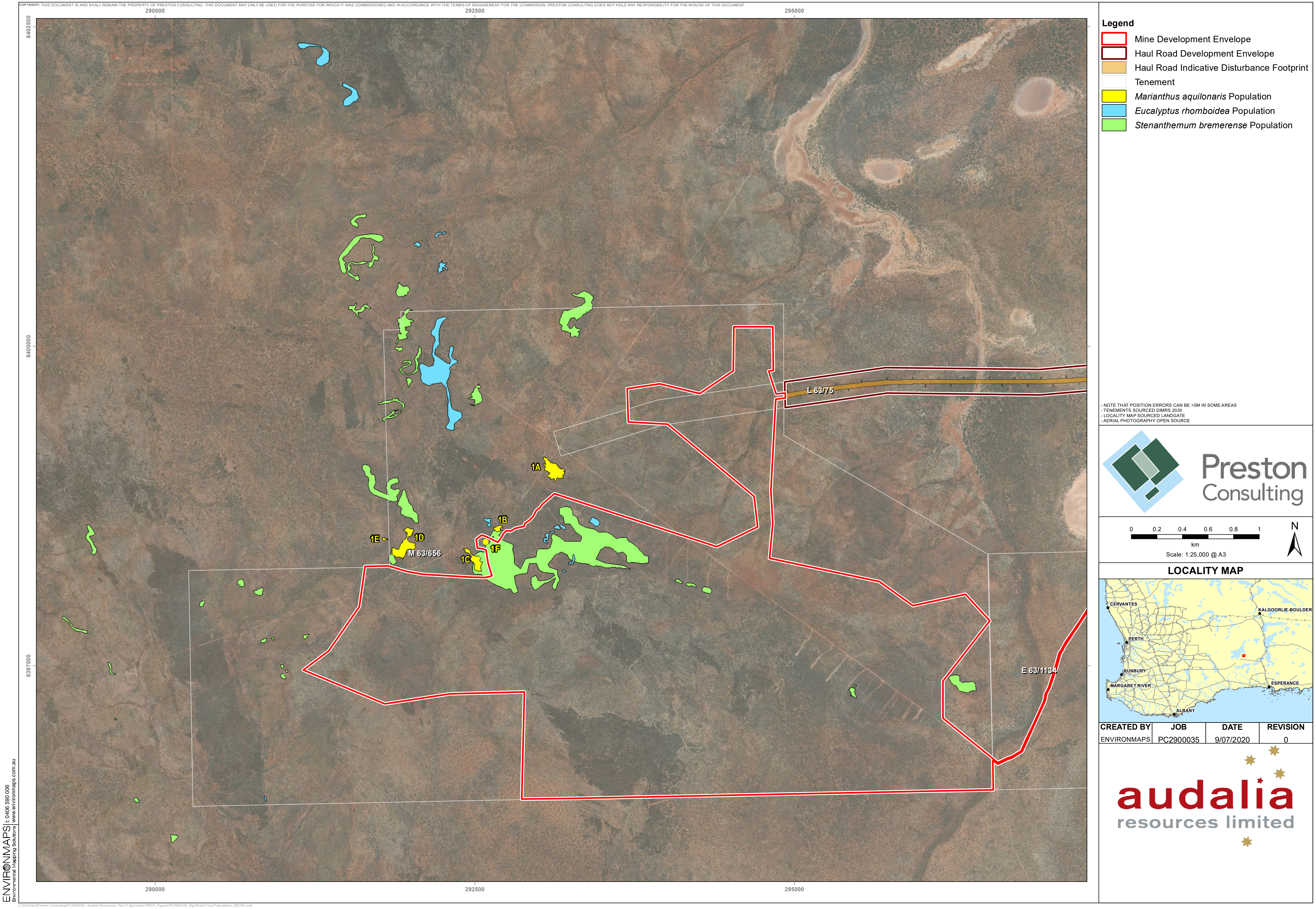


Figure 25: Significant flora populations in proximity to the survey area

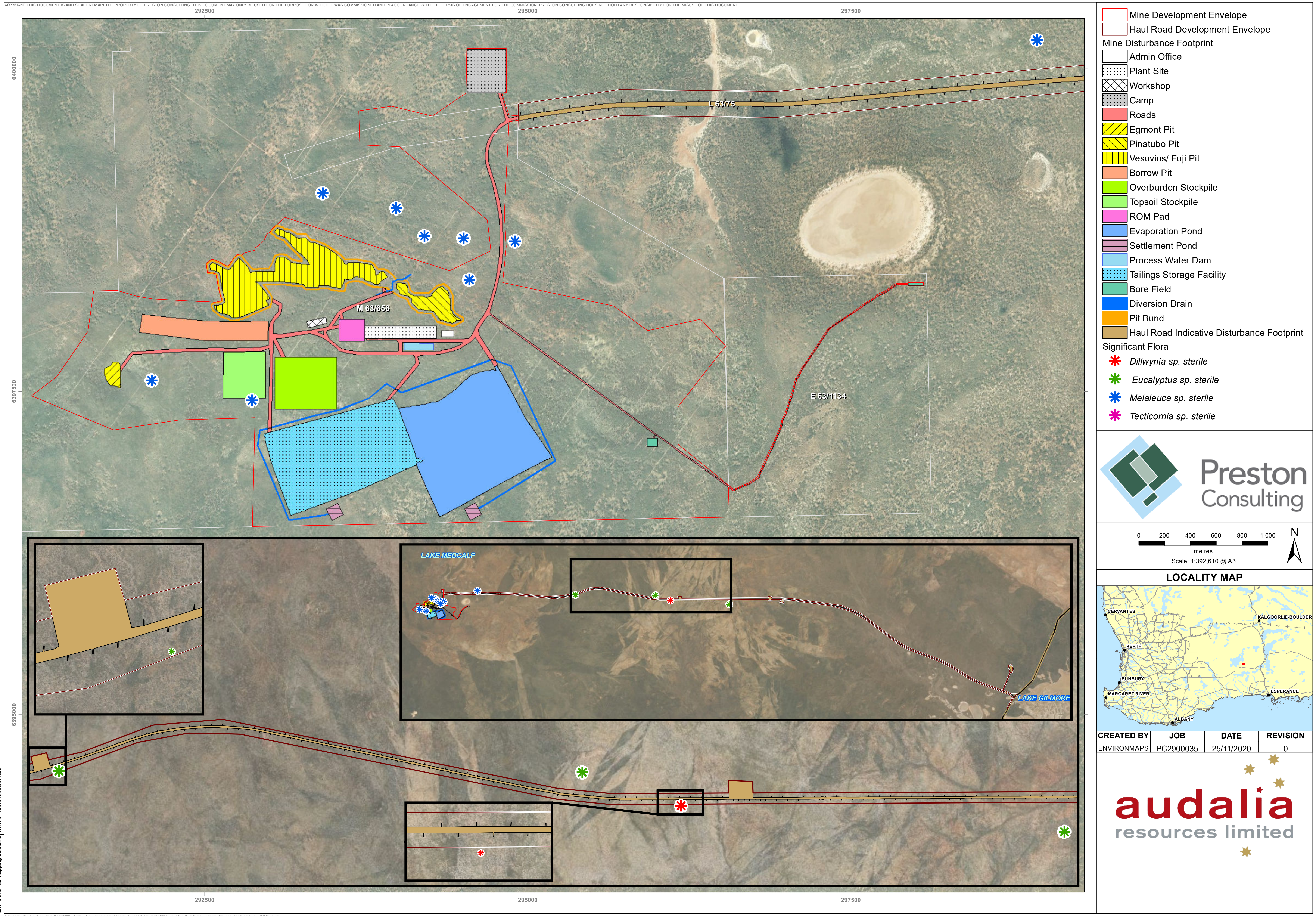


Figure 26: Sterile flora recorded within the survey area

5.3.4 *MARIANTHUS AQUILONARIS* (THREATENED)

Flora and vegetation field surveys within the mine study area identified *M. aquilonaris* which is listed as Threatened under the BC Act. A summary of *M. aquilonaris* conservation status, biology and environmental characteristics and a brief description on germination trials is provided below.

Conservation Status

M. aquilonaris was declared as Rare Flora under the WA *Wildlife Conservation Act 1950* in 2002 under the name *Marianthus* sp. Bremer, and is ranked as Critically Endangered under World Conservation Union (IUCN, 2001) criteria B1ab(iii,v)+2ab(iii,v); C2a(ii) due to its extent of occurrence being less than 100 km^2, its area of occupancy being less than 10 km^2, a continuing decline in the area, extent and/or quality of its habitat and number of mature individuals and there being less than 250 mature individuals known at the time of ranking. However, as more plants have since been found, it no longer meets these criteria and a recommendation will be made by DBCA to the Threatened Species Scientific Committee (TSSC) that they be changed to Critically Endangered B1ab(iii,v)+2ab(iii,v). The species is not currently listed under the EPBC Act. The main threats to the species are mining/exploration, track maintenance and inappropriate fire regimes (DEC, 2010c).

Biology and Ecology

M. aquilonaris is an erect, straggly shrub to 1.6 m high with hairy stems, alternate, elliptic to oblong leaves, a glabrous calyx and a pale blue and white corolla (Figure 27). Flowers appear between September and October. *M. aquilonaris* appears to be a disturbance opportunist as it was found growing in abundance in areas that had been recently burnt (DEC, 2010c).

M. aquilonaris is considered to be a facultative seeder-sprouter, with many plants re-sprouting from basal stock following fire, however plants are also able to germinate from seed. Based on assessments conducted by DBCA, the juvenile period is approximately 36 months (DEC, 2011).

Figure 27: Image of *M. aquilonaris* (from Botanica, 2020e)

Distribution

M. aquilonaris is known only from the Bremer Range which hosts the Bremer Range Priority 1 PEC (Figure 29). The extent of occurrence for this taxon is likely to be less than 0.5 km^2 (DEC, 2010c).

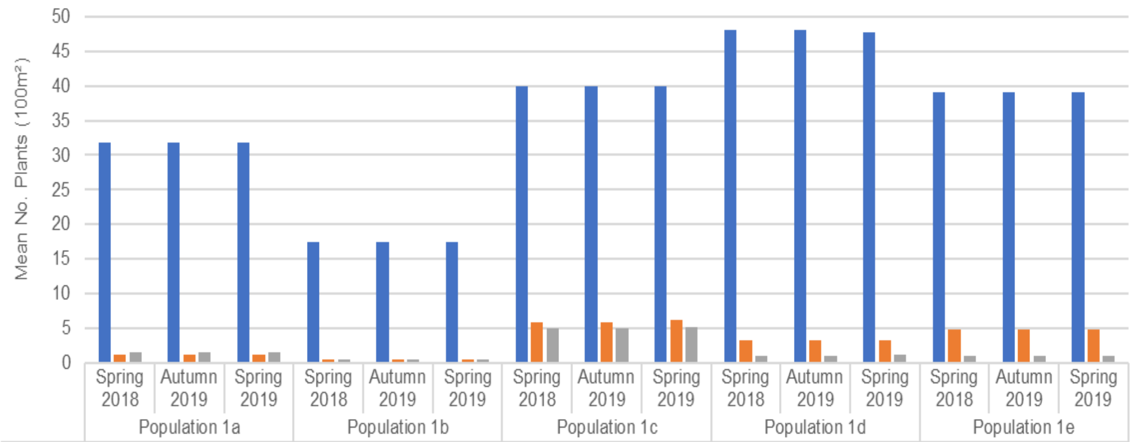
Regional Searches

Assessments on potential habitat for this taxon have been conducted by both DBCA and Botanica. The potential habitats identified were targeted in further survey work, based on similar geology, elevation and associated vegetation. No further populations have been identified by DBCA or Botanica as a result of these searches. From the potential habitat search conducted by Botanica, where a total of 35 potential habitat locations were surveyed, six potential optimal habitats (based on similar habitat and vegetation to known populations) were identified locally (Figure 35).

Sub-population Demographics

Due to the extended duration of demographic monitoring it is not possible at this point in time to identify trends in the reproductive or mortality rates of each sub-population. The data collected in 2018 and 2019 establishes a baseline against which to compare future twice-yearly monitoring results. This will allow estimation of 'effective population size' (that is the proportion of each sub-population that are mature and capable of reproducing), average mortality rates, average reproduction/recruitment rates and age distribution of each sub-population (Botanica, 2020a). Salient findings are summarised below:

- Mature plants consistently outnumber juvenile or dead plants (Figure 28);
- Flowers were only present during the spring monitoring periods (2018 and 2019);
- In Spring 2018, the percentage of fruiting plants ranged from 11% (Population 1e) to 38% (Population 1b), while in Spring 2019, only one quadrat from Population 1d (Q1-2) had fruits present; and
- The mean numbers of fruits and flowers per plant varies between sub-populations and also shows year-to-year variability.



	Population 1a			Population 1b			Population 1c			Population 1d			Population 1e		
	Spring 2018	Autumn 2019	Spring 2019	Spring 2018	Autumn 2019	Spring 2019	Spring 2018	Autumn 2019	Spring 2019	Spring 2018	Autumn 2019	Spring 2019	Spring 2018	Autumn 2019	Spring 2019
Mature	32	32	32	18	18	18	40	40	40	48	48	48	39	39	39
Juvenile	1	1	1	1	1	1	6	6	6	3	3	3	5	5	5
Dead	2	2	2	1	1	1	5	5	5	1	1	1	1	1	1

Figure 28: Age structure of each sub-population (spring 2018 - spring 2019)

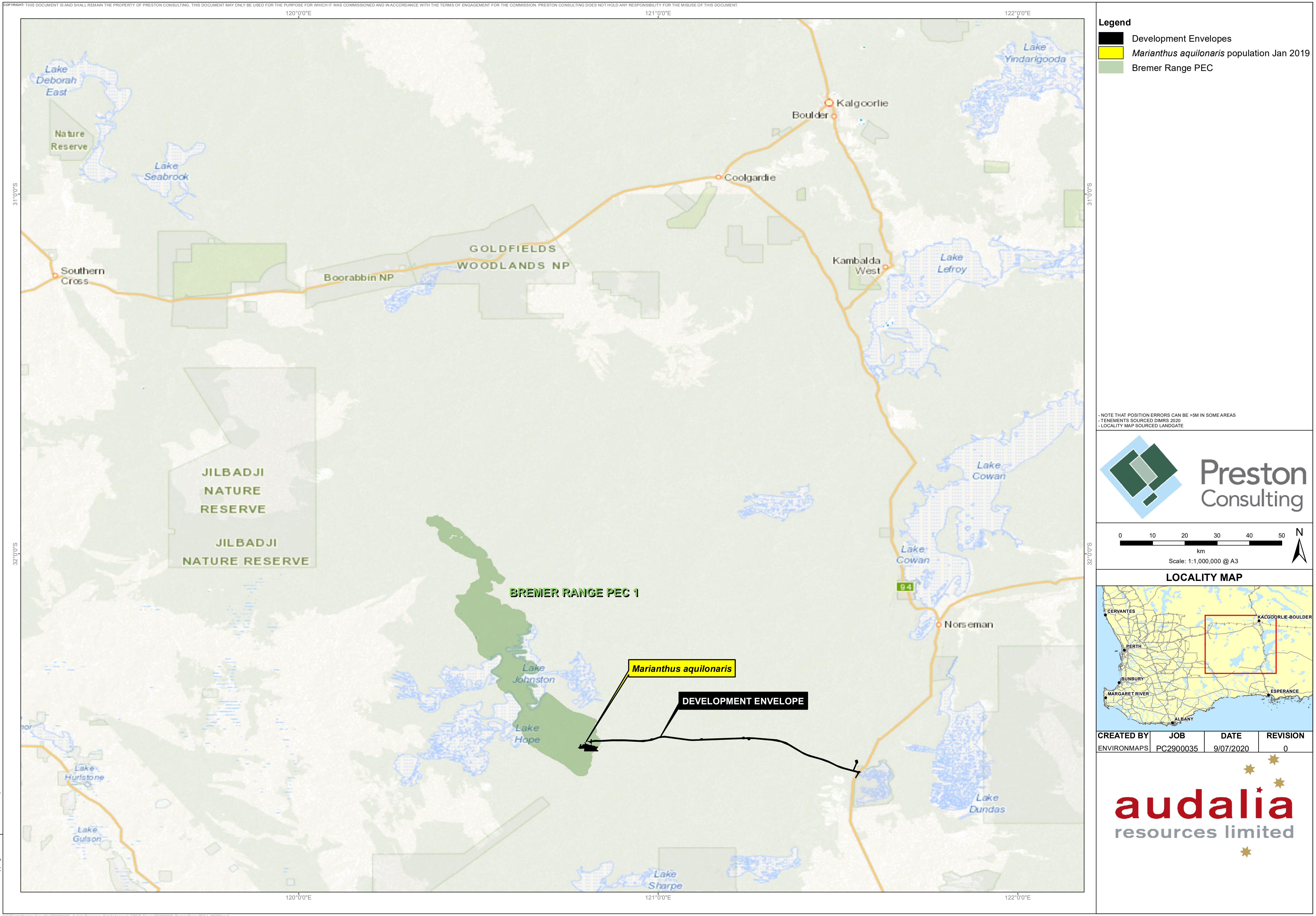


Figure 29: Regional map of Bremer Range and *M. aquilonaris* records

Population Extent

Currently there are six known sub-populations of *M. aquilonaris,* all of which occur within Bremer Range. Population 1a - 1c were previously known sub-populations listed by DBCA during 2011. Sub-population 1d and 1e were newly identified populations located by Botanica in September / October 2014.

Sub-population 1f is a previous record of one individual, last recorded by DBCA in September 2016, which has never been located by Botanica over several attempts (in 2015, 2017 and 2019) despite Botanica being provided with GPS coordinates, DBCA database search records and a photo of the original record (i.e. Botanica was able to verify that they searched the same location as the photo).

Details on the current status of all sub-populations are summarised in Table 17.

Table 17: Summary of *M. aquilonaris* sub-populations

Population No.	DBCA Live Total Count (2011)[1]	DBCA Live Total Count (2015/2016)[2]	Area Occupied (m^2)[3] (2015)	Area Occupied (m^2)[4] (2018)	Population Condition (2018)
1a	9820	2259	25,288	16,050	Moderate
1b	787	247	5,645	2,124	Moderate
1c	7091	3205	16,719	8,668	Healthy
1d	N/A - Sub-populations were not identified	8255	25,400	17,630	Healthy
1e	N/A - Sub-populations were not identified	661	2,200	638	Healthy
1f	N/A - Sub-populations were not identified	1	11	0	N/A - not present
Total	**17,659**	**14,628**	**75,263**	**45,110**	

1 Population monitoring conducted by DBCA in October 2011.
2 Simple plant count conducted by DBCA 29 September 2015 and 7 September 2016 (listed on the TPFL database).
3 Area occupied/ population condition as listed on DBCA TPFL database based on assessments conducted by Botanica and DBCA.
4 Area occupied based on assessments conducted by Botanica 28 - 30 November 2018.

As shown by the DBCA plant counts, plant numbers have declined over time since a mass germination event following bushfires in the area in 2010. Recent observations of the population area were made by Botanica in November 2018, where a number of plants were observed to have died off. Fires in the region in 2019 did not burn any areas within the Mine DE. Plant numbers are expected to continue to decline with increasing time since fire disturbance.

Genetic Studies

Unless otherwise noted, the text in this section is derived from DBCA (2019; Appendix 3.2). Analysis of contribution of each sub-population to the total gene diversity found sub-population 1d, as well as sub-populations 1c and 1e, contain the largest proportion of the gene diversity present across the species. Sub-populations 1a and 1b have less genetic diversity present, although these two sub-populations contain more than half of the private alleles present and removing these would likely result in a loss of allelic diversity.

Population differentiation analysis showed sub-population 1a to have the greatest differentiation from all other sub-populations, consistent with the greater isolation of this sub-population, approximately 600 m from the nearest sub-population 1b. Sub-population 1b also showed high levels of differentiation from other sub-populations even though it is separated from sub-population 1c by only approximately 250 m. Low levels of differentiation were found amongst sub-populations 1c, 1d and 1e. Sub-populations 1d and 1e appear to be genetically connected with a lower differentiation and some admixture between genetic clusters, as expected due to their closer geographic relationship. The level of differentiation among the sub-populations is high given the small geographical distance between them. This suggests that there is limited genetic connectivity among the sub-populations, except for 1d and 1e.

The genetic diversity and differentiation estimates from sub-population 1b with genotypes of all individuals were consistent with the results from 30 samples from each sub-population, confirming that sub-sampling for genetic analysis was a reliable estimate of genetic relationships among sub-populations. The full sampling of sub-population 1b showed a slightly higher inbreeding coefficient and slightly lower heterozygosity estimates. This is likely due to more related individuals being included in the whole population sampling whereas the original sampling of a smaller number of plants would have been carried out across the sub-population to avoid sampling of related individuals. The majority of seedlings (96%) from sub-population 1b were fathered by plants from within sub-population 1b. Additionally, 49% of mothers were also seen to be fathers showing a significant amount of self-pollination. Thus, significant amounts of pollen are being exchanged from within the sub-population, with limited movement between sub-populations.

Analysis of seed has shown that pollen dispersal is occurring across sub-population 1b over distances of approximately 42 m. Pollen dispersal between sub-population 1b and other populations is low with only 4% of seedlings fathered from sub-populations 1c, 1d and 1a, which range from 150 – 465 m away from sub-population 1b.

Overall, the results demonstrate high levels of self-pollination, effective pollen dispersal among plants across the sub-population, and limited pollen immigration into the sub-population from other sub- populations (DBCA, 2019).

Soil Relationship

Western Horticultural Consulting (2019) conducted a soil profile assessment within and around the Audalia Medcalf tenements, identifying five main soil groups:

- Alkaline red shallow loamy duplex;
- Loamy gravel;
- Shallow gravel over indurated mottled zone;
- Stony soils; and
- Shallow gravel.

The assessment had to be completed without any machine-made soil disturbance from within the sub-populations. It showed that current *M. aquilonaris* individuals grow only on the 'Shallow gravel over indurated mottled zone' soils. Of the 18 sites that were described adjacent to *M. aquilonaris* populations, 17 of these were 'Shallow gravel over indurated mottled zone' soils and one location had a soil type that was borderline in being classified as this soil (Figure 16; Western Horticultural Consulting, 2019).

All of the areas of occupancy of *M. aquilonaris* are located on mid to low north-facing slopes of the hill that hosts the Vesuvius deposit. Additional occurrences of this soil type occur to the northeast of the known sub-populations, but are located lower in the landscape (350 - 365 m elevation), and south-west of the known sub-populations, located on the southern face of the hill that hosts the Egmont deposit. These areas that are not occupied by *M. aquilonaris*, but have shallow gravel over indurated mottled zone soil, are considered as sub-optimal habitat as described in the subsequent section below.

The vegetation-type synonymous with *M. aquilonaris* is described as Open Low Woodland dominated by *Eucalyptus livida* over Dwarf Scrub including *Eremophila clavata*, *Pultenaea arida*, *Acacia erinacea*, *Westringia cephalantha* var. *caterva*, *Waitzia fitzgibbonii*, *Asteridea athrixioides* and *Lepidosperma* sp (Botanica, 2020c).

The survey indicates that *M. aquilonaris* does not grow on other shallow soils that contain subsoil layers of lateritic duricrust (ferricrete) or decomposing mafic rocks. The indurated mottled zone appears (based on limited observations) to be continuous, with no apparent cracks. Plant roots may not be able to penetrate this layer. On areas of other soils types, generally 'Shallow gravel' soils have ferricrete in the subsoil, and on soils with decomposing igneous rock in the subsoil there are usually gaps between the rocks which contain soil into which plant roots can grow.

Assuming that *M. aquilonaris* roots do not penetrate the indurated mottled zone, the species must be well adapted to long periods of low water availability. As the species does not grow in surrounding areas of deeper soils that have a higher water holding capacity, it either has a competitive advantage over other species that allow it to survive in the 'Shallow gravel over indurated mottled zone' soils, and/or it is unable to compete in the deeper surrounding soils.

The study also showed that there is a strong relationship between soil pH and the presence of *M. aquilonaris*. The pH_{CaCl} of the 'Shallow gravel over indurated lateritic zone' is acidic (pH_{CaCl} = 3.8 - 6.3). Many of these soils had a pH_{CaCl} of less than 4.5. The pH of the soil affects the availability of nutrients. Phosphorus (P), molybdenum (Mo), magnesium (Mg) and calcium (Ca) become less available to plants at a low soil pH. Aluminium and manganese may reach levels that become toxic to plants. Aluminium concentrations increase rapidly and become toxic for most crop and pasture species at a soil pH_{CaCl} of less than 4.5. It is possible that the low soil pH of the 'Shallow gravel over indurated mottled zone' is a determinant of what species grows on the soil. *M. aquilonaris* is obviously tolerant of low soil pH (Western Horticultural Consulting, 2019) and it may even be obligate for the species.

Associated Vegetation

All of the sub-populations are within areas mapped as 'Regrowth mixed low shrubland on hillslope' (HS-OS1) or 'Regrowth mid open mallee woodland of *Eucalyptus livida* over mid open shrubland of *Hakea pendens* and open low shrubland of *Goodia medicaginea* on hillslope' (HS-MWS1). HS-MWS1 contains *Eucalyptus livida* which Botanica have noted to be present at all areas of occupancy. However, the presence of *E. livida* does not necessarily indicate that *M. aquilonaris* will be present. The fact that insects noted to be visiting *E. livida* (Prendergast, 2019) were also noted on *M. aquilonaris* suggests that potential pollinators are not specific to *M. aquilonaris*, and the heavy and widespread flowering of *E. livida* potentially provides alternative food sources to potential pollinators.

Surrounding vegetation types all occur on deeper colluvial soils that do not contain outcrops of limonite and are therefore not suitable for *M. aquilonaris.*

Hydrogeology

GRM (2020c) conducted hydrogeological and hydrological investigations in November 2018 within and around the Audalia Medcalf tenements to describe the hydrogeology of *M. aquilonaris* habitat.

The modelled catchment water balance appears to be dominated by evapotranspiration, with a small proportion of rainfall reporting to the catchment outlet as runoff in the drainage lines. Total seepage below the root zone, which could recharge groundwater, is generally low. Any significant groundwater recharge is likely to occur in very wet years. However, the presence of eluvium areas could affect this water balance.

The current understanding of the hydrogeological conditions indicate that the *M. aquilonaris* plants are very unlikely to draw water from the regional groundwater table, given that the groundwater is hypersaline and the depth to groundwater is in excess of 45 m (well beyond the expected depth of plant roots).

The rock holes noted in the area near the sub-populations can be seen to pond water for relatively short periods after larger rainfall events. Water in the holes is probably sourced from direct rainfall and runoff from a small catchment and probably lost mainly to evaporation. There could be interaction between the eluvium and rock holes should an area of eluvium intersect the base of the rock holes. However, there currently is no mapping of eluvium for the site.

Surface Water Hydrology

The landscape hosting the *M. aquilonaris* sub-populations is characterised by low hills with exposed rock at or close to the surface, changing to deeper sandy and loamy soils with distance downslope. A number of small catchments drain to the north and south from a central, east-west trending line of hills. There are occasional, discontinuous erosion gullies in the mid slopes. Broad, heavily vegetated drainage lines with no defined channel tend to form in the mid to lower parts of the local catchments.

Runoff is expected to be high from the hilly areas, with shallow flow occurring regularly from relatively small rainfall events. This flow could transport loose *M. aquilonaris* seeds over the ground surface downslope. This is consistent with the mapped plant locations appearing to extend downslope from the catchment divide. Much of this runoff would likely infiltrate into the deeper soils downslope.

The sub-populations are all in the elevation range 375 – 417 m Relative Level (RL). The sites to the north east of the sub-populations with the host soil type (shallow gravel over indurated mottled zone) that are unoccupied by any plants are all located at altitudes less than 380 m RL. On the western side of the sub-populations however, unoccupied sites 5, 6 and 7 are all in the altitude range 400 - 415 m RL.

Geomorphology

The geomorphology assessment (World Technical Services Group Pty Limited, 2019) suggests that based on the geological mapping, flora, fauna, microhydrology and soil surveys the *M. aquilonaris* plants require the following conditions for its survival:

- Fire events;
- Open space;

- Shallow gravels over limonitic mottled zone;
- Acidic soils;
- Low salinity soils;
- Full sun (north facing slopes);
- Elevation between 375 m – 425 m; and
- Rain events.

Landform Analysis

Principal Components Analysis and factor analysis results show that the environmental variables which account for the greatest variability between the '*M. aquilonaris* present' and '*M. aquilonaris* absent' sites were surface soil depth, percentage cover of bare ground, plant litter and exposed bedrock (where bedrock is taken to mean rocky outcrop) (Table 18). On average, the '*M. aquilonaris* present' quadrats had shallower surface soils (ranging from 18 – 58 mm), higher percentage bare ground (ranging from 53 - 72%), higher percentage plant litter (ranging from 21 - 41%) and higher percentage bedrock (8 - 36%) compared to the '*M. aquilonaris* absent' quadrats.

In summary, the sites where *M. aquilonaris* was present exhibit low soil surface depth (<58 mm), high percentage plant litter (>20%), a high proportion of bare ground (>53%) and on occasion exposed rock (>8%). Difference in the morphology of the landform and elevation (within a limited range) had little influence on the habitat associations for *M. aquilonaris*.

Table 18: Landform Monitoring-Summary Data

Population	Marianthus (Present/ Absent)		Morphological Type	Landform Type	Rocky Type	Soil Type	Elevation (m)	Aspect	Bedrock %	Surface Soil depth (mm)	% cover of bare ground	% cover of plant litter
1a	P	Range	Crest - Low Slope	Hill slope	Limonite – No bedrock	Clay - loam	375 – 399	W	0-20%	5-100	50-90	<5-50
		Mean	Mid slope	Hill slope	Limonite	Clay – loam	385	W	8%	18	72	23
	A	Range	Upper slope – Valley		Limonite – No bedrock	Clay – loam	371 – 388	SW – NE	0-10%	30-140	20-90	<5-25
		Mean	Mid slope	Hill slope	No bedrock	Clay – loam	381	W	2%	85	68	14
1b	P	Range	Mid slope	Hill slope	Limonite	Sandy - clay loam	400 – 401	N - NW	20-30%	10-30	50-85	25-40
		Mean	Mid slope	Hill slope	Limonite	Sandy - clay loam	401	N - NW	25%	20	68	33
	A	Range	Upper slope – Mid slope	Hill slope	Limonite	Clay loam-Sandy clay loam	397 – 419	NW – NE	0-30%	40-110	5-60	<5-80
		Mean	Mid slope	Hill slope	Limonite	Clay – loam	407	N	8%	67	34	29
1c	P	Range	Mid slope – Low slope	Hill slope	Limonite	Sandy - clay loam	399 – 417	NW	0-40%	15-90	<5-90	<5-85
		Mean	Mid slope	Hill slope	Limonite	Sandy - clay loam	407	NW	13%	58	53	41
	A	Range	Upper slope – Low slope	Hill slope	Limonite – No bedrock	Sandy - clay loam	400 – 430	N – NW	0-60%	20-110	40-95	<5-30
		Mean	Upper slope	Hill slope	Limonite	Sandy - clay loam	414	NW	11%	56	69	15
1d	P	Range	Crest – Valley	Hill slope	Limonite	Sandy - clay loam	399 – 405	N – S	0-80%	10-100	10-90	5-40

Population	Marianthus (Present/ Absent)		Morphological Type	Landform Type	Rocky Type	Soil Type	Elevation (m)	Aspect	Bedrock %	Surface Soil depth (mm)	% cover of bare ground	% cover of plant litter
		Mean	Crest	Hill slope	Limonite	Sandy - clay loam	402	N	36%	32	65	21
	A	Range	Low slope	Hill slope	Limonite – Ironstone	Sandy - clay loam	403 – 409	SE – NE	0-10%	10-130	40-80	<5-15
		Mean	Low slope	Hill slope	Limonite	Sandy - clay loam	405	NE	2%	85	65	8
1e	P	Range	Upper slope – Low slope	Hill slope – Valley	Limonite – Ironstone	Sandy - clay loam	396 – 402	NE	0-20%	30-60	30-70	15-40
		Mean	Mid slope	Hill slope	Limonite	Sandy - clay loam	399	NE	19%	42	58	25
	A	Range	Upper slope – Low slope	Hill slope	Ironstone	Sandy - clay loam	393 - 405	NE	0%	40-110	25-85	5-25
		Mean	Low slope	Hill slope	Ironstone	Sandy - clay loam	399	NE	0%	78	53	14

Dust Deposition

Audalia has undertaken monthly dust deposition monitoring at the Proposal since October 2018. The monitoring network comprises 12 dust deposition gauges, nine are located within the Mine DE (Figure 30) and two within the Haul Road DE (DGM4 and DGM5; Figure 31). A background gauge is located approximately 18 km north-west of the proposed operations (DGM1). A summary of the monthly dust deposition monitoring results provided by Audalia is presented in Table 19. Monthly average deposition rates range from 0.8 - 1.5 $g/m^2/month$ with up to 5.2 $g/m^2/month$ being recorded over the study period. A significant increase in dust deposition rates is noticeable in the period of March - April 2019 when significant bush fires were occurring in the region (Figure 32).

Table 19: Summary of dust deposition monitoring results

Sampling Period	Exposure Period (Days)[1]	Total Dust Deposition ($g/m^2/month$)											
		DG1A	Mine DE									Haul Road DE	
			DG1B	DG1C	DG1D	DG1E	DGM1	DGM2	DGM3	VES	EGM	DGM4	DGM5
10 Sep – 8 Nov 18	59[2]	0.7	0.5	0.7	0.8	1	0.5	0.7	3	ND	ND	0.7	0.4
8 – 29 Nov 18	21	0.9	0.6	0.7	0.9	1.3	0.5	0.4	0.9	0.4	0.6	3.7	1.3
28 Nov 18 – 8 Jan 19	41	0.3	0.5	0.4	0.5	0.7	0.9	0.3	0.7	1.5	1.6	0.6	0.7
8 Jan – 14 Mar 19	65[2]	2.1	2.2	1.9	2.2	2.2	ND	1.9	2.6	2.0	2.4	1.8	0.9
14 Mar – 16 Apr 19	33	2.7	2.1	1.7	3.1	1.2	5.2	1.8	2.3	0.8	0.8	2.6	3.3
16 Apr – 22 May 19	36	0.4	0.5	0.4	0.6	0.5	2.4	0.3	0.5	0.4	0.5	0.4	2.5
22 May – 3 Jul 19	42/34[3]	0.3	0.3	0.4	0.4	1.3	0.5	0.2	0.3	1.1	1	0.5	0.4
3 – 31 Jul 19	30/36[4]	0.3	0.4	1.1	0.3	0.4	0.5	ND	0.2	0.4	0.6	0.3	0.2
31 Jul – 29 Aug 19	29	0.2	0.4	0.2	0.2	0.5	1.6	0.4	0.3	0.6	0.6	0.3	0.5
Average	-	**0.9**	**0.8**	**0.8**	**1.0**	**1.0**	**1.5**	**0.8**	**1.2**	**0.9**	**1.0**	**1.2**	**1.1**

Notes:
1. Typical exposure period specified in AS3580.10.1:2016 is 30±2 days.
2. Presence of fire prohibited collection of dust deposition gauge within monthly period.
3. Sample exposure period is 34 days for DGM4 and DGM5 and 42 days for all other gauges.
4. Sample exposure period is 36 days for DGM4 and DGM5 and 30 days for all other gauges.
ND = No data.

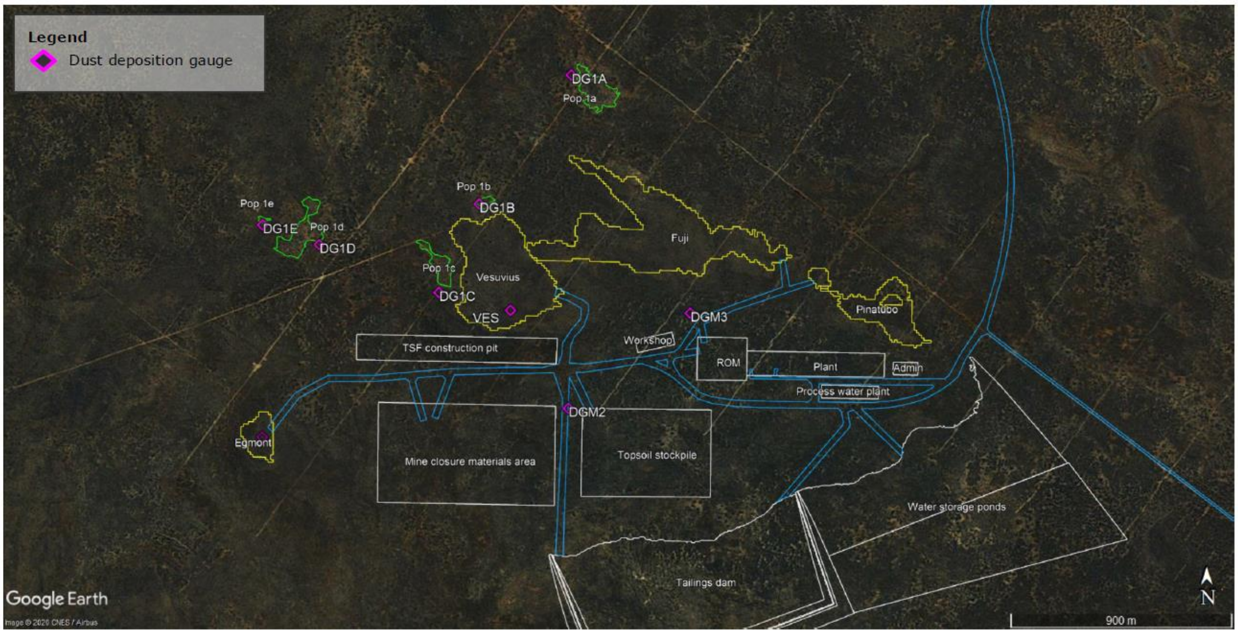


Figure 30: Locations of dust deposition monitors (in purple) – mine site

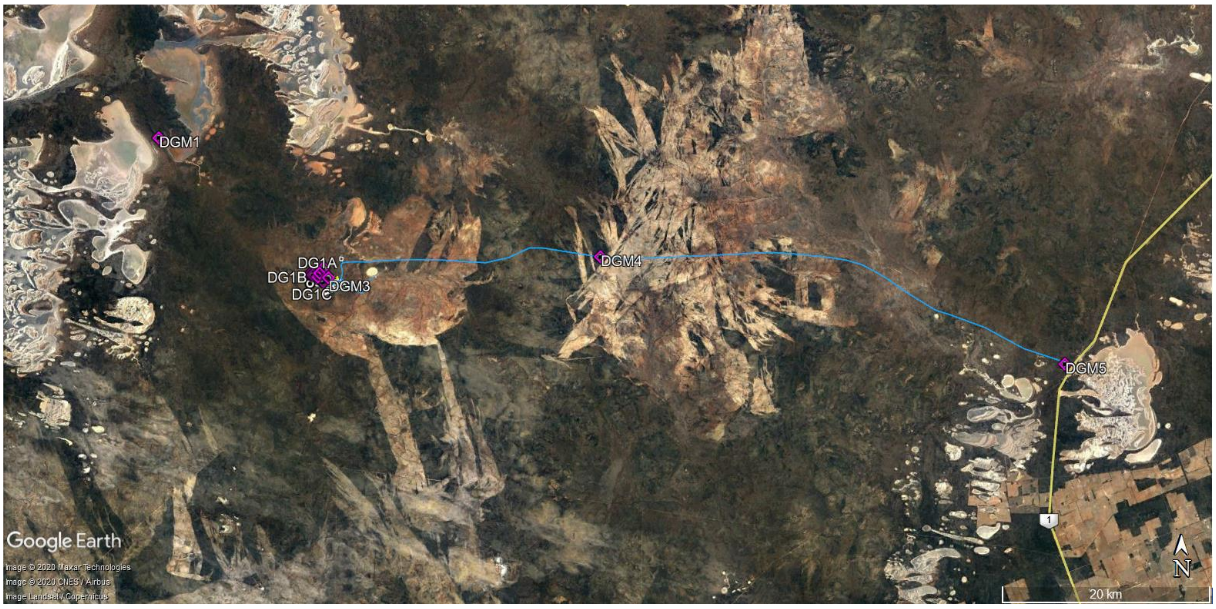


Figure 31: Locations of Dust Deposition Monitors – Haul Road

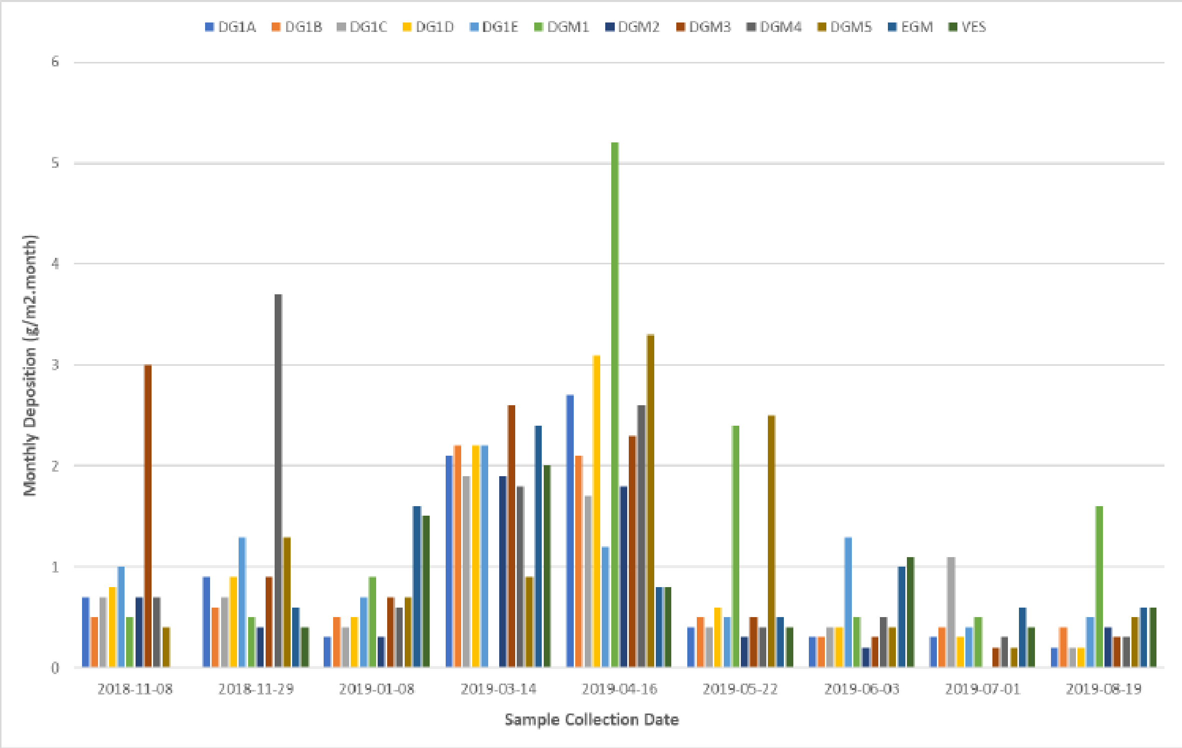


Figure 32: Summary of monthly dust deposition rates

Critical Habitat

This section reviews the habitat information for *M. aquilonaris* based on historical and recent studies. Note that the term 'critical habitat' in this ERD is for EIA purposes and does not refer to the definition of critical habitat in the BC Act.

Typical habitat for *M. aquilonaris* has been defined by DEC (2011) as: Ironstone ridges (ca. 400 m above sea level) with a laterite capping and exposed iron oxide (commonly referred to as limonite). Plants tend to be located within shallow drainage lines on the ridge, on rocky red-orange sandy loam. Habitat is Open Low Woodland dominated by *E. livida* over Dwarf Scrub dominated by *Eremophila clavata*, *Pultenaea arida*, *Acacia erinacea*, *Westringia cephalantha* var. *caterva*, *Waitzia fitzgibbonii*, *Asteridea athrixioides* and *Lepidosperma* sp.

In 2011, DBCA defined habitat critical to the survival of *M. aquilonaris* as follows:

> *…the area of occupancy of* [known] *populations, areas of similar habitat surrounding and linking populations (these providing potential habitat for population expansion and for pollinators), additional occurrences of similar habitat that may contain undiscovered populations of the species or be suitable for future translocations, and the local catchment for the surface and/or groundwater that maintains the habitat of the species* (DEC, 2011).

Previous mapping of the critical habitat for *M. aquilonaris* was conducted by DBCA in 2011 based on the definition above. The resulting map defines critical habitat of *M. aquilonaris* around the immediate area where the (then known) populations occur and the habitat linking them (Figure 33). The resulting critical habitat includes areas of the ironstone ridge which feed shallow drainage lines where large numbers of plants are observed to occur (DEC, 2011). It includes areas of high elevation and south facing slopes that were possibly considered to be similar habitat (topographically similar) and have potential to find undiscovered populations. The mapping was completed prior to identification of sub-population 1d - 1f and hence excludes them.

As required by the ESD (Audalia, 2019), further studies have been conducted for *M. aquilonaris* to facilitate impact assessment for the Proposal. The required studies included further surface soil testing within / outside of the sub-population extents, establishment of demographic monitoring, landform monitoring and hydrological studies in order to further define the habitat, and specifically to identify critical habitat, optimal habitat and sub-optimal habitat for *M. aquilonaris*. The results of these studies have been used to inform the definition of critical habitat proposed in Botanica (2020e) and presented in this ERD.

Based on these assessments, habitat preferences for *M. aquilonaris* include:

- Gravelly, shallow loamy soils with an indurated, mottled zone layer that occurs within 30 cm of the soil surface (referred to as 'Shallow gravel over indurated mottled zone' soil);
- Acidic to neutral soils (pH 4.5 - 7) and low salinity soils (<200 mS/m);
- Shallow brown to orange / red-brown sandy-clay loam soils / loamy earths (≤58 mm depth);
- Areas of exposed bedrock (predominately limonite ≥8%) with high percentage plant litter (≥20%) and bare ground (≥53%);
- Elevations ranging from 375 m – 425 m with the north-eastern sub-populations (1a and 1b) occurring lower in the landscape of the Bremer Range (380 – 405 m) and the north-western sub-populations (1c, 1d and 1e) occurring higher in the landscape (400 m - 425 m); and
- North-eastern and north-western face of rocky slopes which is likely associated with the surface drainage of the hills which generally drains toward the north.

A map of the proposed critical habitat for *M. aquilonaris* (including areas of additional occurrences of similar habitat that may contain undiscovered populations of the species or be suitable for future translocations) is provided in Figure 34. A summary of the aspects used in determining the potential boundary of the proposed critical habitat (based on the definition provided by DBCA (DEC, 2011) is provided in Table 20.

Table 20: *M. aquilonaris* critical habitat definition

DBCA Definition (DEC, 2011)	Botanica Assessment
Habitat critical to the survival of *M. aquilonaris* includes:	
Area of occupancy of populations	Known occurrence of *M. aquilonaris* populations
Areas of similar habitat surrounding and linking populations (these providing potential habitat for population expansion and for pollinators)	Areas of shallow gravel over indurated mottled zones identified during soil investigations conducted by Neil Lantzke (Western Horticultural Consulting, 2019)
	Area of suitable habitat between the populations which includes rocky hillslopes and vegetation types mapped by Botanica Consulting (Botanica, 2017a) which are known to support *M. aquilonaris* populations; HS-MWS1 (*E. livida*) and HS-OS1 (regrowth shrubs)
	Low to mid north facing slopes. Mottled zone has only been identified between elevation 380 m – 425 m. No *M. aquilonaris* located on the upper slope/ hill crest likely due to absence of mottle zone and greater exposure
Additional occurrences of similar habitat that may contain undiscovered populations of the	Areas of shallow gravel over indurated mottled zones identified during soil investigations conducted by Western Horticultural Consulting (2019) on low-mid north facing slopes with *E. livida* vegetation

DBCA Definition (DEC, 2011)	Botanica Assessment
species or be suitable for future translocations	
The local catchment for the surface and / or groundwater that maintains the habitat of the species	Catchment above the sub-populations including the catchment area that would drain through the actual area occupied by *M. aquilonaris* and the catchment area that would drain through the shallow gravel over indurated mottled zone soil type. Surface drainage flow of the range extends in a northern direction as assessed by GRM (2020c). *M. aquilonaris* plants are very unlikely to draw water from the regional groundwater table, given that the groundwater is hypersaline and the depth to groundwater is in excess of 45 m (GRM, 2020c)

Optimal Habitat

It is proposed to adopt the areas of 'Shallow gravel over indurated mottled zone' soil type within the critical habitat boundary (majority of which contains the *M. aquilonaris* sub-populations) as optimal habitat on the basis that it is the only soil type upon which the species is known to currently exist. Based on the DBCA definition of critical habitat (Table 20) the area proposed as 'optimal habitat' meets all the critical habitat definition criteria excluding area of occupancy, with some sections of the optimal habitat not currently occupied by *M. aquilonaris*. A map of the optimal habitat is provided in Figure 35. The previous record of *M. aquilonaris* population 1f has not been included in optimal habitat as this population (which included a single plant that has not been observed/ identified since 2016) does not occur on the shallow gravel over indurated mottled zone soil type. The historic record of population 1f has been included in the sub-optimal habitat of the critical habitat boundary, which is described below.

Sub-Optimal Habitat

Sub-optimal habitat is considered to be area that the species may be able to grow, but is not preferred or optimal. Sub-optimal habitat has been identified as the habitat within the critical habitat boundary, outside of the area of occupancy and optimal habitat, as well as areas of the 'Shallow gravel over indurated mottled zone' soil type that occurs outside the critical habitat boundary. Logically this may extend further in distance, include other soil and vegetation types, landscape positions etc., but it needs to be limited in some way to enable definition of areas. Based on the DBCA definition of critical habitat (Table 20) the area proposed as 'sub-optimal habitat' only meets the following critical habitat criteria; Areas of similar habitat surrounding and linking populations (these providing potential habitat for population expansion and for pollinators). A map of the sub-optimal habitat is provided in Figure 35.

A summary of the extent of proposed critical habitat, optimal habitat and sub-optimal habitat (including the area of *M. aquilonaris* occupied and unoccupied within each habitat) is provided in Table 21.

Table 21: Extent of Critical, Optimal and Sub-optimal Habitat

Habitat	Extent (ha)	*M. aquilonaris* occupied area (ha)	*M. aquilonaris* unoccupied area (ha)
Critical Habitat	64.50	4.51	59.99
Optimal Habitat	16.82	4.51	12.31
Sub-Optimal Habitat	52.57	0	52.57

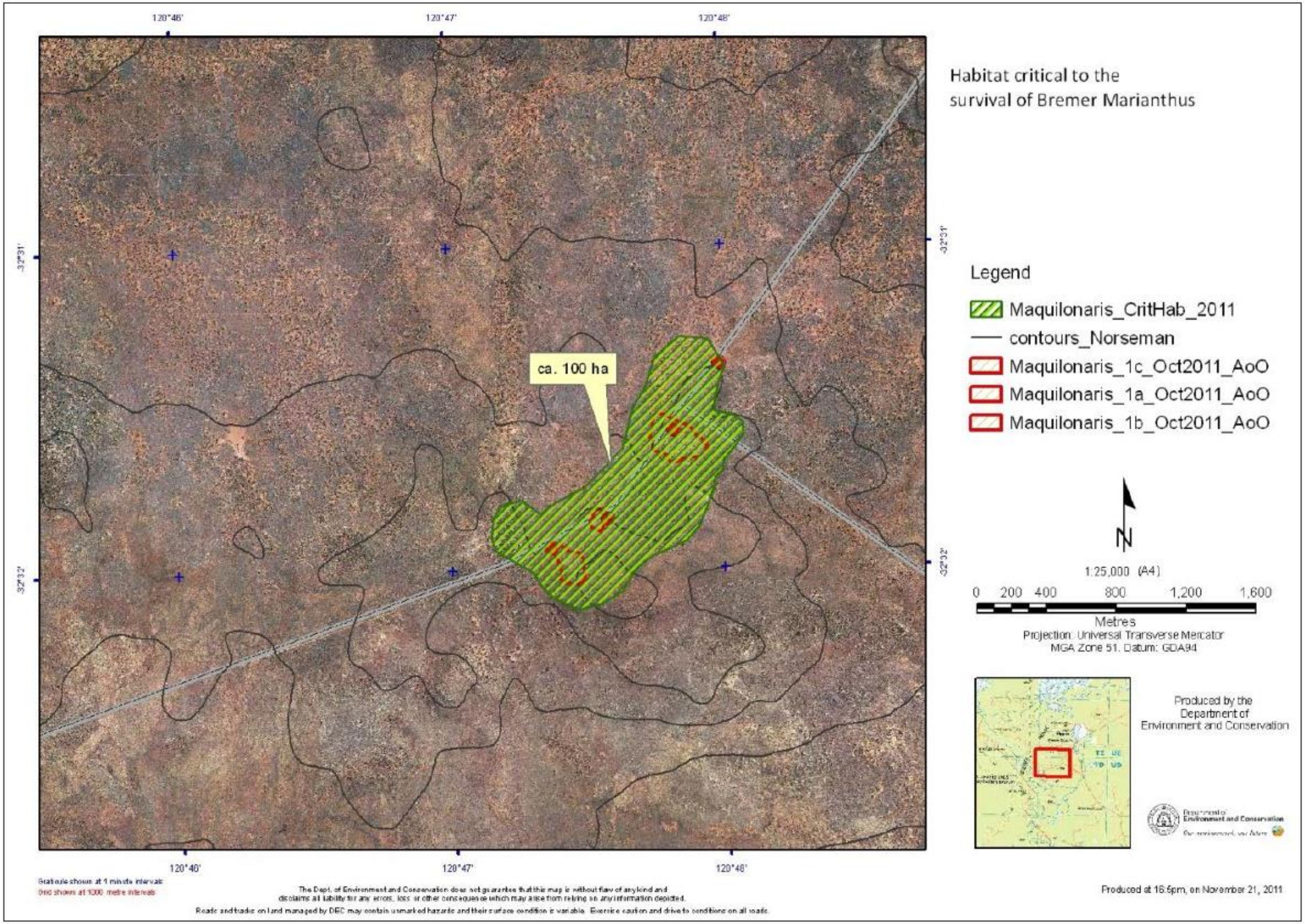


Figure 33: Critical habitat originally mapped for *M. aquilonaris* (DEC, 2011)

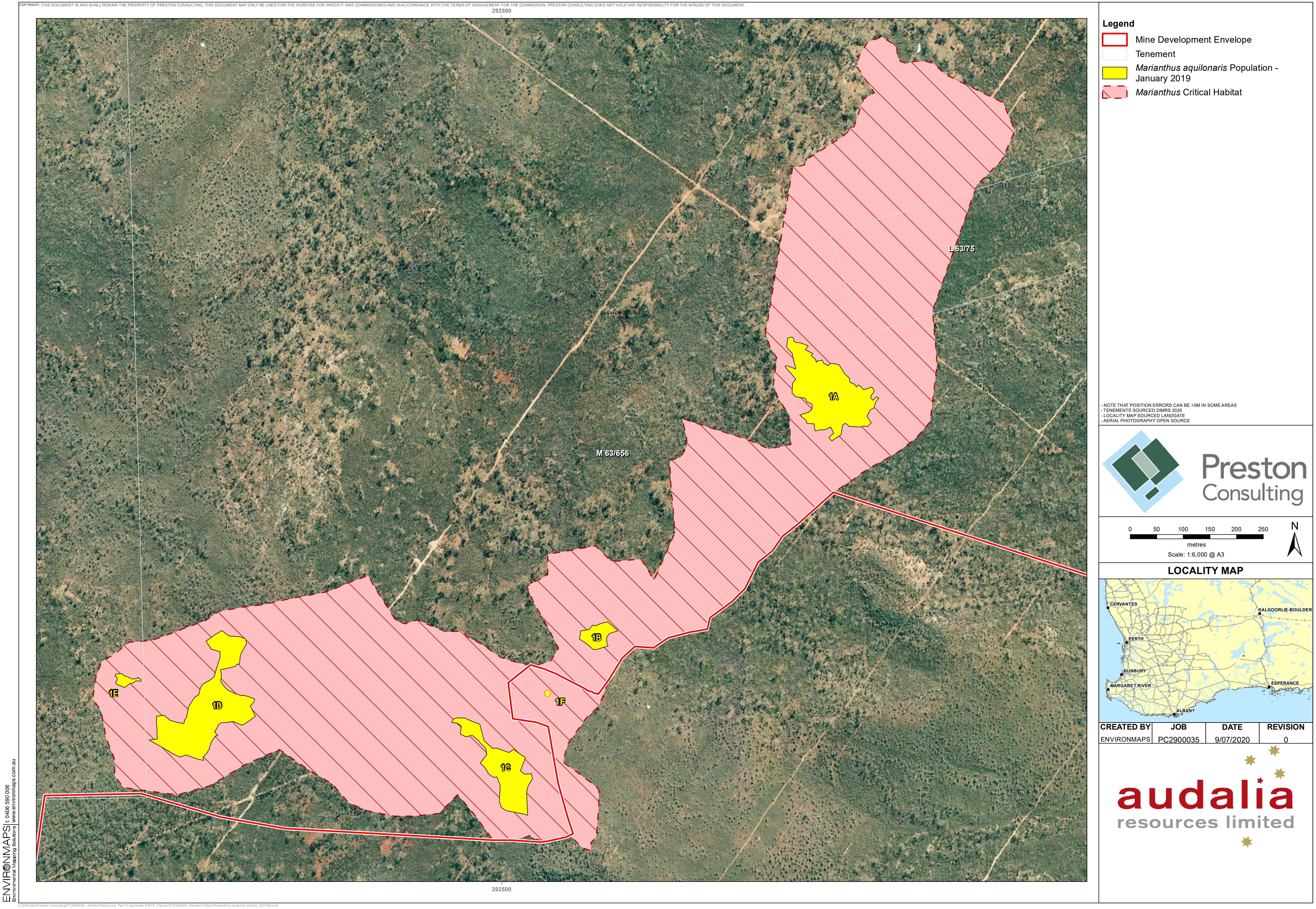


Figure 34: Revised critical habitat boundary for *M. aquilonaris*

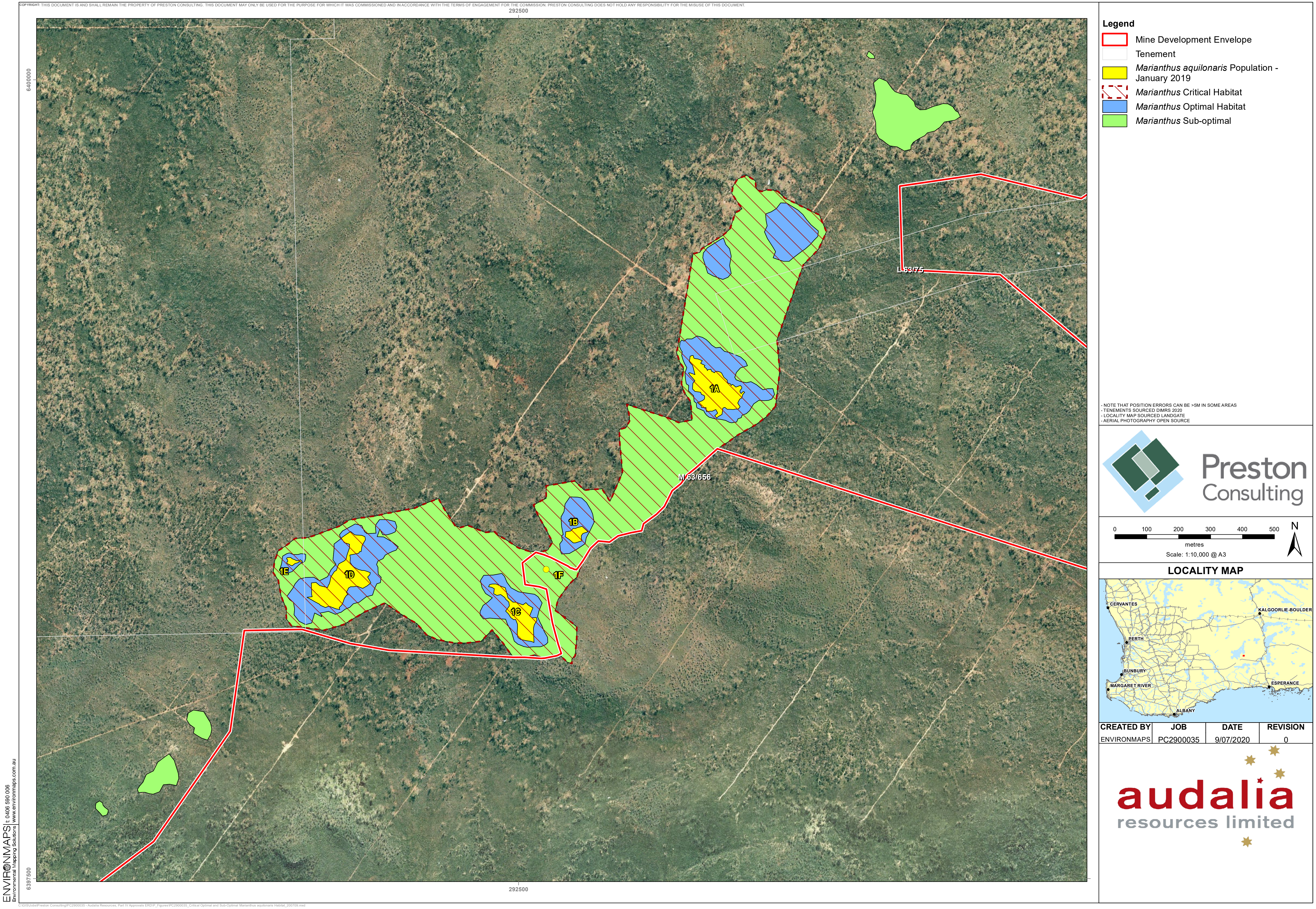


Figure 35: Critical, optimal and sub-optimal habitat

Germination Trials

Botanica have completed one cutting trial which showed that *M. aquilonaris* could survive up to 18 days, but with no successful establishment of cuttings. Note that cuttings can take many months to strike and require specific temperatures and moisture content (Botanica, 2020b; Appendix 3.8).

Seed quality measurements for the four seed collections submitted for assessment by DBCA are presented in Table 22. The collections of *M. aquilonaris* had high purity and high germination.

Table 22: Seed quality characteristics of *M. aquilonaris* seed collections

Initial collection weight (g)		20.5
Collection dry weight (g)		20.0
SAMPLE	**Weight/seed (g)**	1.83 x10^{-3}
	Seed per g	546
	Purity (%)	89.1
PURE	**Weight/seed (g)**	1.63 x 10-3
	Seed per g	612
Seed in collection (*estimated)		10,890*
Cut test		0.97
Germination (% ± S.E.) (#ongoing)		85 ± 9
Tetrazolium viability (%)		NA

DBCA (2019) also completed germination of *M. aquilonaris* to support the genetic studies. 45 seeds from each mother, had the seed coat nicked with a scalpel blade. Seeds were then soaked in a 10% solution of Plant Preservative Material for 15 min before being placed onto agar containing 100 mg/L Gibberellic Acid. Gibberellic Acid (filter sterilised) was added to autoclaved water agar that had cooled to a temperature of 60°C. Plates were incubated at 15°C with light/dark cycles of 12 hours. Between 30 and 110 seeds were gathered from ten mother plants, with germination of 7 - 29 seeds from each mother plant (10 - 36% germination).

Population Viability

The computer modelling program, VORTEX was chosen to run the analysis. VORTEX is an individual-based simulation model for Population Viability Analysis (PVA) and is the most widely deployed PVA platform available (Brook *et al.*, 2000). VORTEX models population dynamics as discrete, sequential events that occur according to defined probabilities (Miller & Lacy, 2005). The model is repeated to reveal the distribution of fates that the population might experience under a given set of input conditions (Miller & Lacy, 2005).

Initial analysis was conducted; however, it was evident that PVA software was not suitable to assess *M. aquilonaris* as long-term demographic / census monitoring data is not currently available to inform the attributes of the discrete sequential events, reducing the validity of the modelling predictions. The demographic data acquisition commenced by the Proposal will be central to completing PVA at a later date, if required. The modelling also did not have the capacity to take into account the re-sprouting capabilities of *M. aquilonaris.* Finally, PVA is generally utilised to model different scenarios, with the intent to model the difference between direct impacts to different sub-populations vs no direct impacts and different translocation scenarios, however as no direct impacts from the Proposal are proposed, there were no scenarios to assess.

Genetic diversity studies have shown that all sub-populations have moderate levels of genetic diversity, with sub-population 1d showing the largest range of genetic diversity, followed by populations 1c and 1e. Sub-populations 1a and 1b are less representative of the gene diversity present than other sub-populations; however, they do contain more than half of the private alleles present. Analysis of the contribution of each sub-population to the total maximal gene diversity found sub-population 1d to harbor a large proportion of the total gene diversity present across all the sub-populations, followed by sub-population 1c.

The impacts on total genetic diversity caused by removing each sub-population showed variable but small outcomes. The gene diversity is slightly increased if sub-populations 1a and 1b are removed, this is likely a reflection of the lower heterozygosity found at these sites. Gene diversity is decreased the most when sub-population 1d is removed (DBCA, 2019).

All sub-populations were found to have negative inbreeding coefficients, suggesting that mating is not occurring between related or genetically similar individuals (DBCA, 2019). Results of pollination studies demonstrate high levels of self-pollination, effective pollen dispersal among plants across the sub-population, and limited pollen immigration between sub-populations (DBCA, 2019).

Given the current absence of inbreeding depression, limited effect on the genetic diversity when removing different sub-populations, limited pollen transfer between populations, no proposed direct impacts to any of the sub-populations, and potential indirect impacts related to dust emissions are anticipated to only occur within sub-population 1b, it is unlikely that mining will reduce the viability of sub-populations.

5.3.5 *EUCALYPTUS RHOMBOIDEA* (P4)

This eucalypt is a small to medium-sized woodland tree that is restricted to areas of greenstone geology in an area of the Bremer Range between Mt Glass and Mt Gordon and midway between Lake King and Norseman, a linear range of approximately 15 km (Hopper & Nicolle, 2007). It is endemic to WA.

Its name arose due to its rhomboid-shaped (diamond) buds. The bark is smooth throughout, and the leaves are light green to grey-green/blue-green. The bark is coloured creamy-grey to orange-brown and sheds in strips and/or short ribbons. The species' flowers are pale yellow and have been recorded in September and October. The buds begin to form in April and both buds and fruits can be present in May (Hopper & Nicolle, 2007).

Eucalyptus rhomboidea is currently considered a Priority 4 species, but has been nominated to the TSSC for a revision, where it is expected to become a Threatened Flora, under an Endangered ranking (as of 16 July 2019). Under the BC Act, the Ministerial guideline (2) establishes criteria for the listing of a Threatened species under Part 2, Division 1, Subdivision 2 of the Act. A species marked in the endangered category are considered to face a very high risk of extinction, in the wild, in the near future. Specifically, *E. rhomboidea* is being considered for Criterions B1 and B2. Criterion B is based upon the species current geographic range (DBCA, 2018b).

Criteria nominated as applicable to *E. rhomboidea* include:

B1. Extent of occurrence estimated to be less than 5,000 km^2:

a. Severely fragmented OR known to exist at no more than five locations; and
b. Continuing to decline, observed (estimated), inferred or projected, in any of the following:
   i. Area, extent and/or quality of habitat; and
   ii. Number of mature individuals.

B2. Area of occupancy estimated to be less than 500 km^2:

a. Severely fragmented or known to exist at no more than five locations; and
b. Continuing to decline, observed (estimated), inferred or projected, in any of the following:
   iii. Area, extent and/or quality of habitat; and
   iv. Number of mature individuals.

The coincidence of mining within greenstone belt ranges containing localised mineral prospectivity and promising economic prosperity has been the catalyst for the increase in protection levels for many endemic species, such as *E. rhomboidea* of the Bremer Range.

The low woodland type that *E. rhomboidea* is characterised by:

> "Low trees of *Eucalyptus eremophila* occurred in Eucalyptus sp. (now known *rhomboidea*) Low Woodland. Tall shrubs included *Melaleuca lanceolata*, and low shrubs, *Acacia poliochroa* sens. lat., *A. rendlei*, *Eremophila caerulea*, *M. marginata* (Sond.) and *Westringia cephalantha*" (published report for Lake Johnston – Hyden: Newbey & Hnatiuk, 1988) (Hopper & Nicolle, 2007).

Unpublished field notes by Henry-Hall *et al* for the proposed Bremer Range Nature Reserve in 1990 described the vegetation community of Bremer Range area as:

> "The diverse eucalypt woodlands present on the Bremer Range uplands include the endemic *E. rhomboidea* with *E. salubris, E. flocktoniae*, *E. salmonophloia* and *E. cylindrocarpa* over *Melaleuca* spp. At Mt Glasse, E. rhomboidea was recorded with *E. salubris, E. gracilis, E. eremophila* and *E. densa* over mallees *E. pileata*, *E. cylindriflora* and *E. leptophylla"* (Hopper & Nicolle, 2007).

E. rhomboidea is a non-sprouting species, only regenerating via seed after fire (Hopper & Nicolle, 2007).

Botanica recorded 5,730 individuals of this species within the survey area, within four floristic communities:

1. Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain;
2. Mid mallee shrubland of *E.* spp. over mid shrubland of *Melaleuca pauperiflora* and mixed low shrubland on clay-loam plain;
3. Regrowth mid open mallee woodland of *E. livida* over mid open shrubland of *Hakea pendens* and open low shrubland of *Goodia medicaginea* on hillslope; and
4. Mid open mallee woodland of *E. livida* over heathland of *Allocasuarina / Hakea / Melaleuca* and open low sedge of *Lepidosperma sanguinolentum* on hillslope.

Critical Habitat

The text in the following sections have been taken from Botanica (2020f), provided in Appendix 3.14.

Critical habitat for *E. rhomboidea* includes area of occupancy, optimal habitat and sub-optimal habitat. Because of the need to retain linkages between populations for potential pollinators, is proposed that all landforms and vegetation units between populations (which have been identified as sub-optimal habitat) be considered part of the critical habitat. Maps of the critical habitat for *E. rhomboidea* are provided in Figure 36.

A summary of the extent of proposed critical habitat, optimal habitat and sub-optimal habitat (including the occupied and unoccupied area within each habitat) is provided in Table 23.

Table 23: Extent of *E. rhomboidea* Critical, Optimal and Sub-optimal Habitat

Habitat	Extent (ha)	Occupied area (ha)	Unoccupied area (ha)
Critical Habitat	42,775	12*	42,763
Optimal Habitat	2481	12*	2,469
Sub-optimal Habitat	40,294	0	40,294

*Excludes fire impacted populations

Optimal Habitat

Optimal habitat has been designated as the habitat immediately surrounding *E. rhomboidea* and populations, based on known affiliations with geology, soil, landscape position, landform, drainage and vegetation associations (based on local studies conducted for each species at Bremer Range) with no apparent physical, chemical or biological reason why the plants could not grow in this habitat.

Figure 36 shows the optimal habitat for *E. rhomboidea.* It grows on a range of soil groups at a range of positions in the landscape. This species was found growing on 'Alkaline red shallow loamy duplex' soils that occur on the lower, mid and upper slopes. It was found growing on 'Loamy gravel' soils on the lateritic plateau at the top of the landscape and on the mid slopes. It was also found growing on 'Shallow gravel' soils, below a breakaway (Western Horticultural Consulting, 2019*). E. rhomboidea* was found in a variety of habitats including within creeklines and low to mid gravelly rises and lateritic slopes (Botanica pers. comms).

E. rhomboidea populations were identified within a variety of vegetation types mapped by Botanica including *E. salmonophloia* woodland (CLP-EW1), Mallee woodland over *Melaleuca pauperiflora* (CLP-MWS1), *E. livida mallee* woodland (HS-MWS1) and *E. livida mallee* woodland over heathland of *Allocasuarina/ Hakea/ Melaleuca* (HS-MWS3).

Sub-optimal Habitat

Sub-optimal habitat is considered to be area that the species may be able to grow, but is not preferred or optimal. Sub-optimal habitat has been identified as the habitat within the critical habitat boundary, outside of the area of occupancy and optimal habitat. Logically this may extend further in distance, include other soil and vegetation types, landscape positions etc, but it needs to be limited in some way to enable definition of areas. The extent of sub-optimal habitat has been based on local studies conducted for each species at Bremer Range and a combination of spatial boundaries of both soil landscape systems / soil mapping units and pre-European vegetation associations within which each species has been previously recorded.

As shown in Figure 37, *E. rhomboidea* occurs in two soil landscape systems/ soil mapping units, obtained from the DPIRD database (2014) and Geoscience Australia (2009). *E. rhomboidea* occurs on a variety of soils and landforms ranging from mid to low lateritic rises-greenstone hillslopes and creeklines.

E. rhomboidea occurs within two broad pre-European vegetation associations, including Morell and Dundas Blackbutt woodland and mallee scrub.

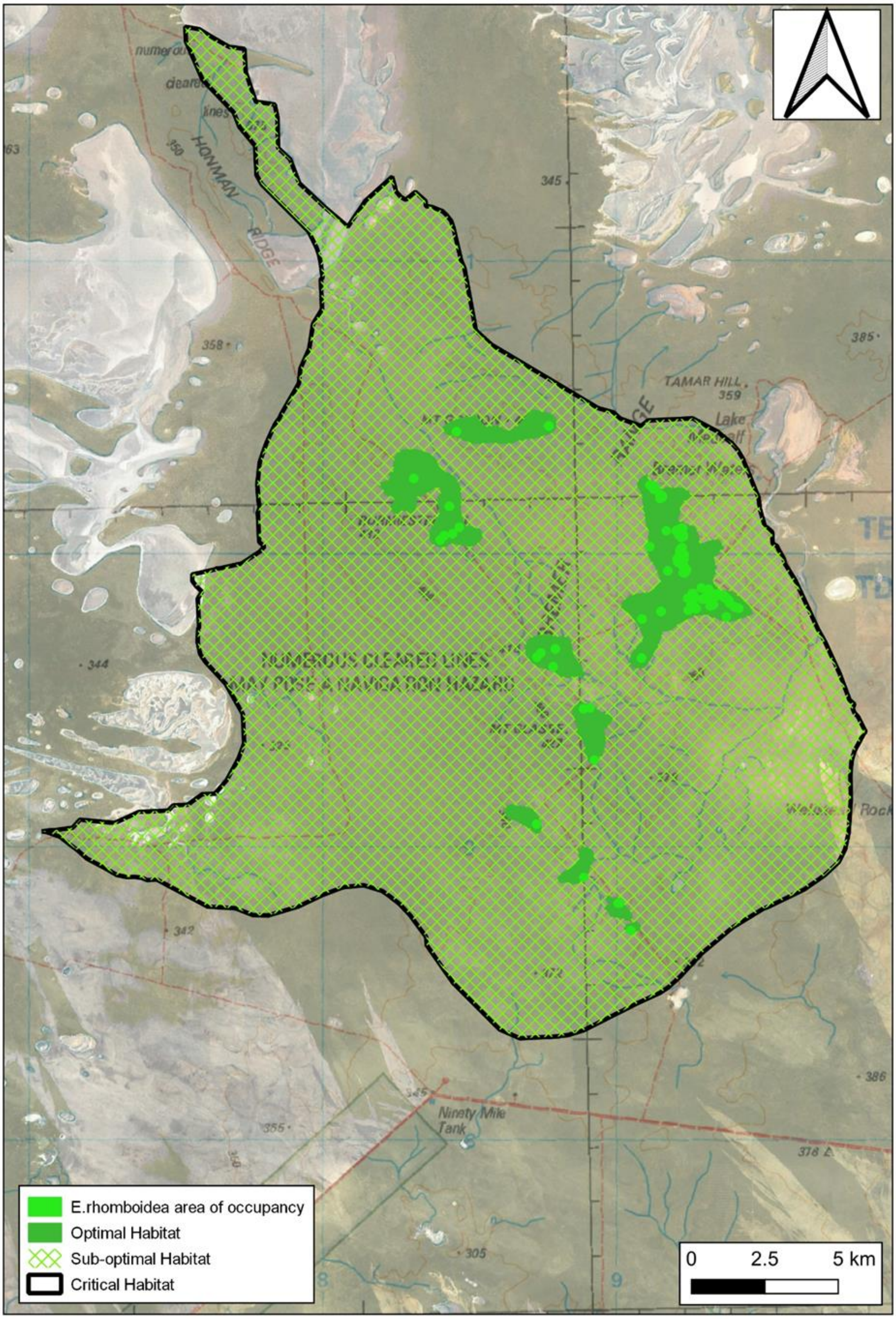


Figure 36: Critical, optimal and sub-optimal habitat for *E. rhomboidea*

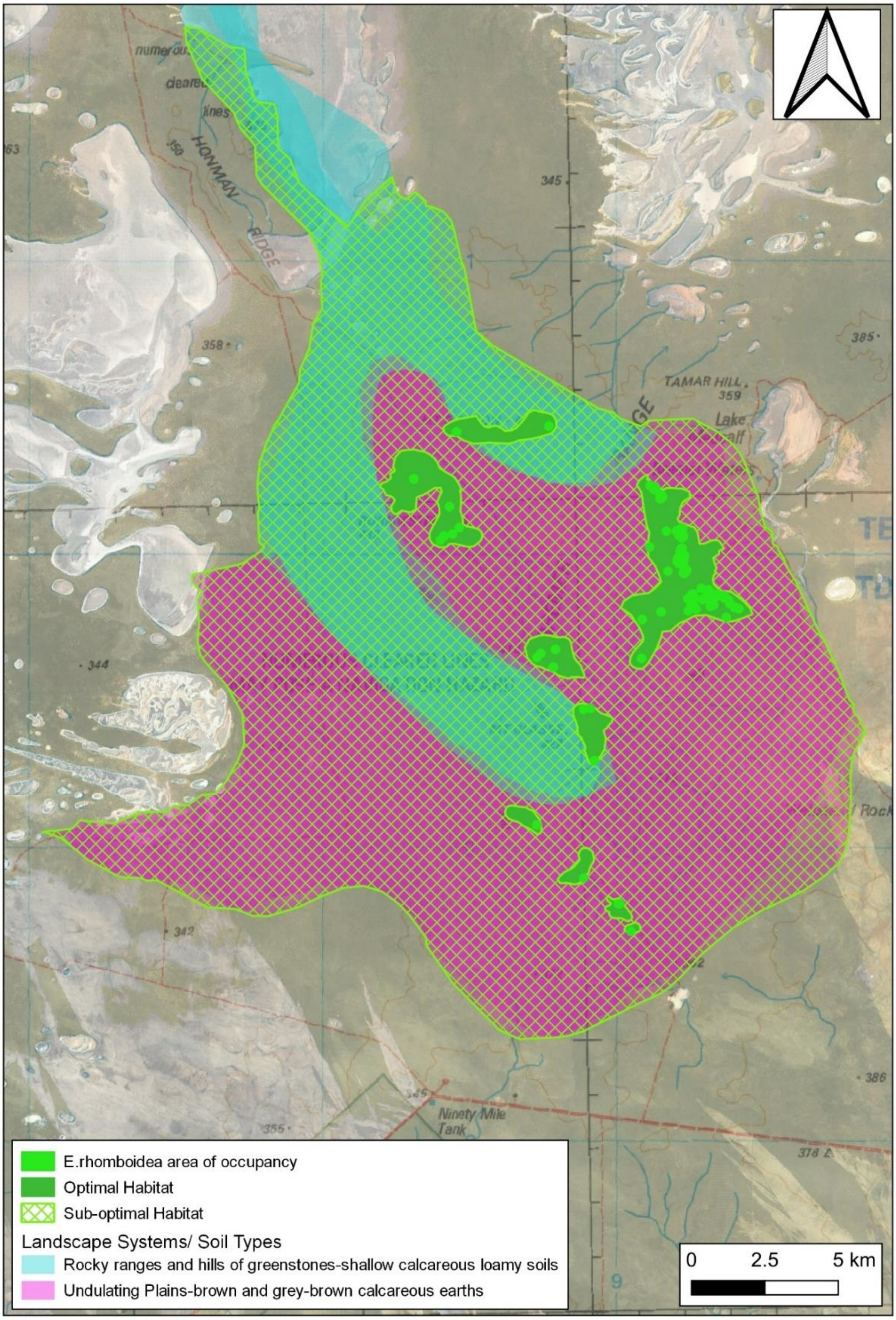


Figure 37: Soil and landscape systems associated with *E. rhomboidea* critical habitat

5.3.6 *STENANTHEMUM BREMERENSE* (P4)

Stenanthemum bremerense is known from the Bremer Range and Marvel Loch areas (Collins, & Lullfitz, 2009) and is known to occupy a range of approximately 180 km (Tianye SXO Gold Mining Pty Ltd, 2017), restricted to the Coolgardie IBRA region (Mattiske, 2019). The majority of records are within the Bremer Range, with an isolated collection near Marvel Loch (Rye, 2007).

The species is often located within mixed *Allocasuarina* and *Melaleuca* shrublands on clay loam soils, and sometimes in mixed *Acacia, Allocasuarina* and *Eucalyptus* shrubland on clay-loam plains (Tianye SXO Gold Mining Pty Ltd, 2017). *S. bremerense* prefers sandy or gravelly loams associated with lateritic outcrops and breakaways (Mattiske, 2019; Botanica, 2017a). The species occurs on the top or sides of outcrops or any other sites with lateritic gravel or pebbles. The species is highly common in some localities, with one population containing thousands of plants (Rye, 2007).

S. bremerense is described as an erect or low spreading shrub reaching 0.3 - 0.6 m in height, and uncommonly, up to 1.4 m high (Mattiske, 2019). It has been recorded flowering between April - June and October - November (Collins, & Lullfitz, 2009). It is often single-stemmed at the base, but can be multi-branched. The inflorescence is clustered, sometimes with few flowers but can have many on the one cluster, measuring 5 - 12 mm in diameter. The flowers are white and described as shortly clawed and spreading (Mattiske, 2019).

Botanica recorded 30,211 individuals of *S. bremerense* within five floristic communities:

1. Low open woodland of *Eucalyptus salmonophloia* over mixed shrubs on clay-loam plain;
2. Mid mallee shrubland of *Eucalyptus* spp. over mid shrubland of *Melaleuca pauperiflora* and mixed low shrubland on clay-loam plain;
3. Regrowth mid open mallee woodland *Eucalyptus livida* over mid open shrubland of *Hakea pendens* and open low shrubland of *Goodia medicaginea* on hillslope;
4. Mid open mallee woodland over *Eucalyptus livida* over heathland of *Allocasuarina / Hakea / Melaleuca* and open low sedge of *Lepidosperma sanguinolentum* on hillslope; and
5. Regrowth mixed low shrubland on hillslope.

Critical Habitat

The text in the following sections have been taken from Botanica (2020f), provided in Appendix 3.14.

Critical habitat for *S. bremerense* includes area of occupancy, optimal habitat and critical habitat. Because of the need to retain linkages between populations for potential pollinators, is proposed that all landforms and vegetation units between populations (which have been identified as sub-optimal habitat) be considered critical habitat. Maps of the critical habitat for *S. bremerense* are provided in Figure 38.

A summary of the extent of proposed critical habitat, optimal habitat and sub-optimal habitat (including the occupied and unoccupied area within each habitat) is provided in Table 39.

Table 24: Extent of Critical, Optimal and Sub-Optimal Habitat

Habitat	Extent (ha)	Occupied area (ha)	Unoccupied area (ha)
Critical Habitat	221,008	56*	220,952
Optimal Habitat	23,554	56*	23,498

Habitat	Extent (ha)	Occupied area (ha)	Unoccupied area (ha)
Sub-optimal Habitat	197,454	0	197,454

*Excludes fire impacted populations

Optimal Habitat

Optimal habitat has been designated as the habitat immediately surrounding *S. bremerense* populations, based on known affiliations with geology, soil, landscape position, landform, drainage and vegetation associations (based on local studies conducted for each species at Bremer Range) with no apparent physical, chemical or biological reason why the plants could not grow in this habitat.

Figure 38 shows the optimal habitat for *S. bremerense*. It grows in loamy gravel soils and is found on the lateritic plateau at the top of the landscape and on areas of gravelly rises on the mid to lower slopes (Western Horticultural Consulting, 2019). *S. bremerense* was found in a variety of habitats including sandy / gravelly plains to low rise and lateritic slopes / ridges (Botanica pers. comms).

S. bremerense populations were identified within a variety of vegetation types mapped by Botanica including Mallee woodland over *Melaleuca pauperiflora* (CLP-MWS1), *E. livida mallee woodland* (HS-MWS1), *E. livida mallee* woodland over heathland of *Allocasuarina/ Hakea/ Melaleuca* (HS-MWS3) and Regrowth mixed low shrubland (HS-OS1).

Sub-optimal Habitat

Sub-optimal habitat is considered to be area that the species may be able to grow, but is not preferred or optimal. Sub-optimal habitat has been identified as the habitat within the critical habitat boundary, outside of the area of occupancy and optimal habitat. Logically this may extend further in distance, include other soil and vegetation types, landscape positions etc, but it needs to be limited in some way to enable definition of areas. The extent of sub-optimal habitat has been based on local studies conducted for each species at Bremer Range and a combination of spatial boundaries of both soil landscape systems/ soil mapping units and pre-European vegetation associations within which each species has been previously recorded.

As shown in Figure 39, *S. bremerense* occurs in four soil landscape systems/ soil mapping units, obtained from the DPIRD database (2014) and Geoscience Australia (2009). *S. bremerense* occurs on a variety of soils on the top or sides of laterite outcrops and breakaways and in other sites with lateritic gravel or pebbles.

S. bremerense occurs within eight broad pre-European vegetation associations, including Morell and Dundas Blackbutt woodland, Salmon gum and Morrel woodland, *E. transcontinentalis* woodland, mallee scrub, Casuarina thicket on greenstone hills and Acacia / Casuarina / Melaleuca thicket.

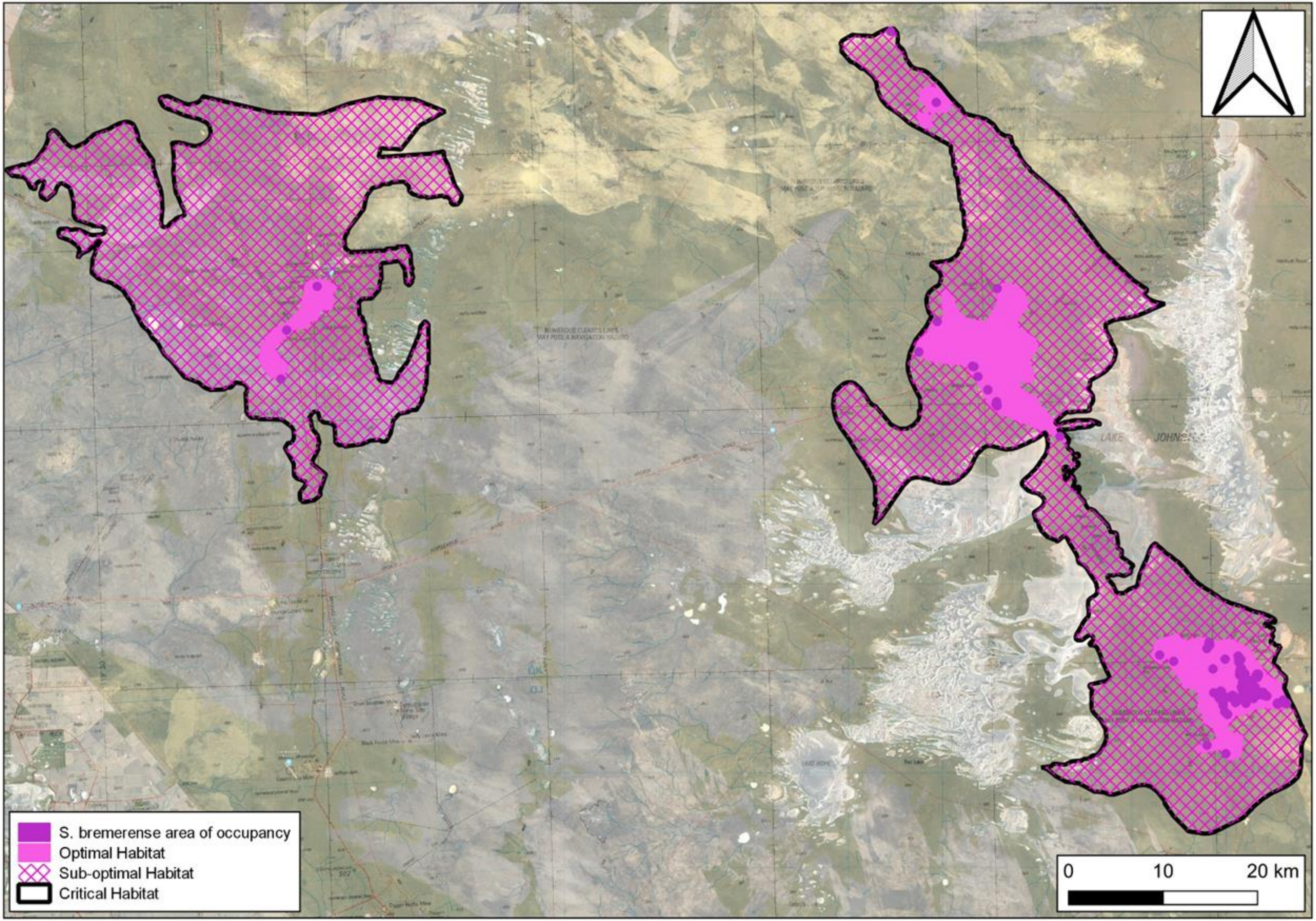


Figure 38: Critical, optimal and sub-optimal habitat for *S. bremerense*

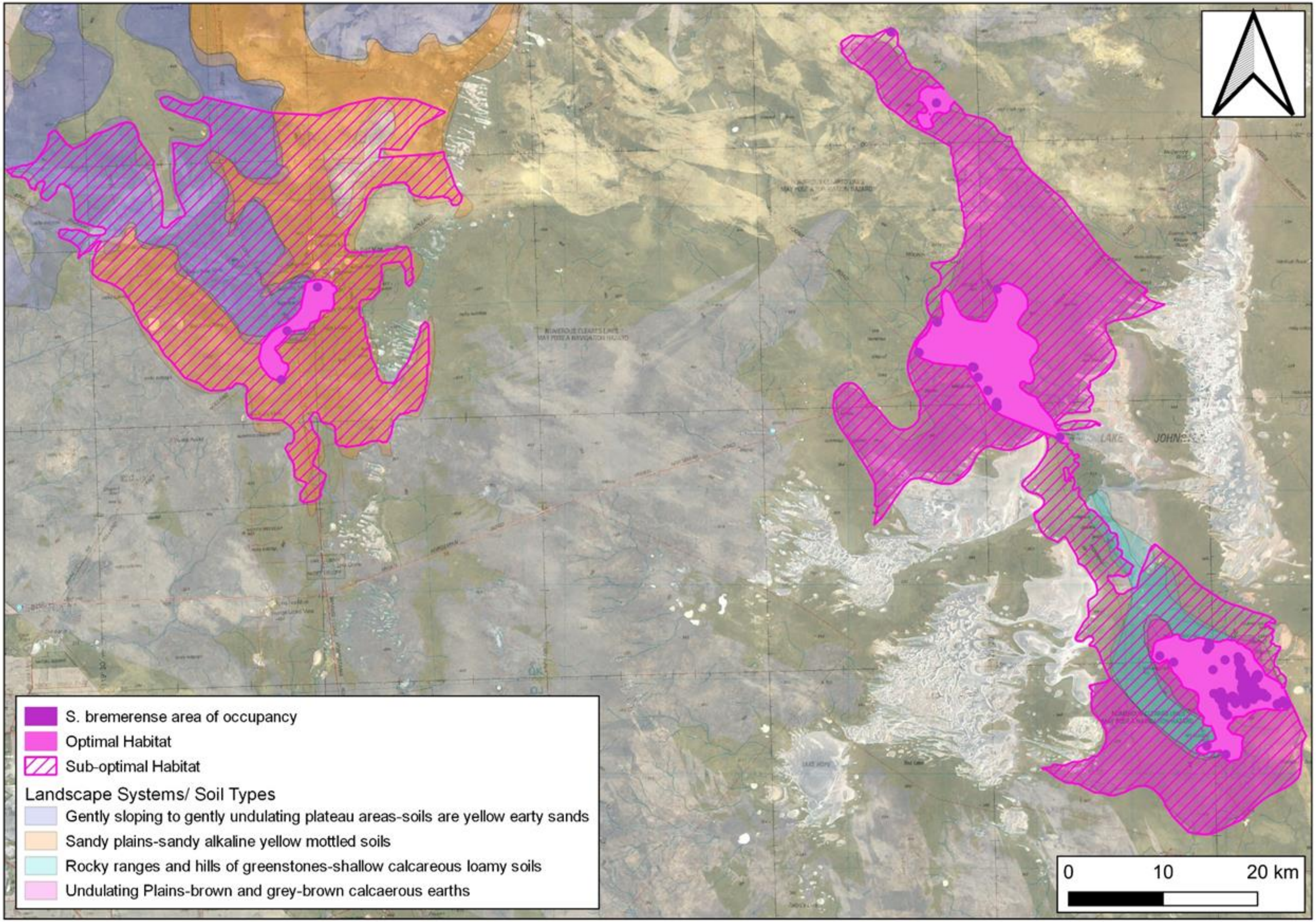


Figure 39: Soil and landscape systems associated with *S. bremerense* critical habitat

5.3.7 Other Priority Flora

Acacia hystrix subsp. continua (P1)

Acacia hystrix subsp. *continua* is described as a shrub growing to 1 m tall and 3 m wide with leaves reduced to phyllodes (narrow spines). Leaves are 2.5 – 6.5 cm long and are continuous with the branchlet. The morphology of the leaves is a diagnostic feature for the subspecies and an epithet to the name, *continua*. It is known only from north of Salmon Gums where it is relatively abundant. It grows in red-brown clay-loam along diffuse watercourses in eucalypt woodland with dense myrtaceous understory (Wattle, 2018; Maslin, 1999). Flowering time has been recorded in September and mature pods recorded in December. The species flowers yellow.

Botanica recorded 100 individuals of *A. hystrix* subsp. *continua* in one floristic community; Low open woodland of *Eucalyptus salmonophloia* over mixed shrubs on clay-loam plain.

Acacia mutabilis subsp. stipulifera (P3)

This species is described as a spreading shrub that grows to a height of 0.3 m - 1 m. It grows within loamy sand to clay in slightly saline soils, within salt lake systems. Its flowers are yellow and occur in August to September. The species is known from Lake Cobham, south of Newdegate, near Lake Bryde and Lake Magenta (DEC, 2012).

A. mutabilis subsp. *stipulifera* is more tolerant to salinity and waterlogging combined than other *Acacia* species (Horsnell, 2008). It usually occurs in low woodland of *Eucalyptus kondinensis* and *E. occidentalis* (World Wide Wattle, 2018). Botanica located 348,311 (estimate) individuals of the species within five floristic communities:

1. Low open woodland of *Eucalyptus salmonophloia* over mixed shrubs on clay-loam plain;
2. Mid mallee shrubland of *Eucalyptus* spp. over mid shrubland of *Melaleuca pauperiflora* and mixed low shrubland on clay-loam plain;
3. Mid mallee woodland of *Eucalyptus* spp. over mixed low shrubland/ heathland on clay-loam plain;
4. Mid sparse mallee shrubland of *Eucalyptus eremophila* over heathland of *Melaleuca* spp. on sand-loam plain; and
5. Regrowth mid sparse mallee shrubland of *Eucalyptus* spp. over low open shrubland of *Acacia / Grevillea* spp. and open hummock grassland of *Triodia scariosa* on sand-loam plain.

Bossiaea flexuosa (P3)

Bossiaea flexuosa is a compact shrub growing to 60 cm in height and 1.5 m wide. The species does not have a single distinct axis, but rather several stems that arise from the rootstock. Its name refers to the flexuose or “zigzag” shape of the branches. The flowers are either solitary, in pairs or in threes at the nodes of the branch. The flowers are coloured inside, a golden-yellow with a reddish-brown margin and a pinkish-red basal “tongue”, and externally, the colour is a deep red to pinkish brown when only a bud, but yellow diffusing into blush-pink when open (Ross, 2006). Flowering time is between September and November.

B. flexuosa occurs in the Roe, Eyre and Coolgardie Botanical Districts around 40 km northwest of Norseman, in the north, and 140 km east of Hyden in the west, and southwards towards Salmon Gums and the Young River. The species prefers deep sandy soil on sandplains (kwongan), sometimes adjacent the edges of salt lakes (Ecoscape, 2017), and open mallee or eucalypt woodland. Associated dominant species are *Eucalyptus tetragona*, *Callitris tuberculata* and *Melaleuca linguiformis*.

Botanica recorded 100 individuals of *B. flexuosa* from one floristic community: Mid sparse mallee shrubland of *Eucalyptus eremophila* over heathland of *Melaleuca* spp. on sand-loam plain.

Brachyloma stenolobum (P1)

Brachyloma stenolobum is an erect shrub reaching 1.5 m high and 1.2 m wide. It is single-stemmed at ground level and then separates into branchlets. The single-stem is present due to its fire-sensitive rootstock. The inflorescence' is erect to widely spreading, with usually one flower, but occasionally two, per branchlet. The flower is narrowly triangular, thick and fleshy and spreads into 5 lobes (star-like). This is a unique species, one of the only WA species of *Brachyloma* that contains white flowers which are narrow and lobed, with the lobes keeling upwards and gently recurving outwards (Hislop & Cranfield, 2014). The species' peak flowering time is likely between April and June, and dependant on the extent of late spring to early autumn rainfall. The species early flowering stages can be seen in May.

B. stenolobum is known only from the Forrestania area, southwest of the Coolgardie bioregion. However, Botanica recorded a location within the survey area that represents a range extension that is 100 km west from the Forrestania region. It is known to occur on yellow sandplains within heathland. 500 individuals of this species were recorded by Botanica within one floristic community; Mid mallee woodland of *Eucalyptus* spp. over mixed low shrubland/ heathland on clay-loam plain. . *B. stenolobum* is also known to occur with *Allocasuarina spinosissima*, *Acacia heteroneura*, *Melaleuca cordata* and *M. calyptroides.*

More individuals are likely to be collected in future survey work, however it is not expected to have a wide distribution as the first collection was made in 2002. Its preferred habitat is largely intact and moderately common. Its previous known population in Forrestania is scattered across 2.5 km, but the plants are common at the two sites (Hislop & Cranfield, 2014).

Eucalyptus pterocarpa (P3)

Eucalyptus pterocarpa is described as a small tree (a mallet) growing 10 - 15 m tall and bark that is smooth, grey over salmon to copper in colour and sheds in long ribbons (Craig & Coates, 2001; Euclid, 2019). The inflorescence contains clusters of three flowers, which are unbranched. The species produced white flowers between September and November. The buds and fruits are strongly ribbed all over, and the buds taper into a point, which are distinguishing features for this species. *E. pterocarpa* also has ruby-red to red-brown and shiny seeds, unlike its similar-species counterparts (Craig & Coates, 2001).

E. pterocarpa is distributed 90 km west and northwest of Norseman. It occurs on red-brown loam, yellow-brown silty loam soils of creek edges ad rocky slopes (Botanica, 2020c) and grows in open low woodland with *E. salmonophloia, E. dundasii, E. calycogona*, and *E. flocktoniae* with undershrubs of *Acacia merrallii* (Craig & Coates, 2001). *E. pterocarpa* is considered to be one of the more restricted species in its distribution of southwest WA plants.

E. pterocarpa has been used as an example to model the impact of climate change, where 'suitable' climatic conditions for the species was greatly reduced by 2030, and eliminated in 2070, with projected rises in temperature reaching 0.85°C and 2.3°C respectively (Booth, Williams & Belbin, 2012). However, it is recognised that species have varying vulnerabilities to changes in conditions, and it is known that local plant populations are not always optimally adapted to the environments that they occur, having potential to persist under conditions significantly warmer and/or drier than within their current range (Booth *et al*, 2012).

Botanica recorded 100 individuals of this species in one floristic community; Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain.

Hakea pendens (P3)

Hakea pendens occurs in the Parker Range area, on ironstone or on stony ridges with stony loam in mixed scrub, and lateritic ridge tops of the greenstone belt extending south to Cheriton's Find and northeast to Harris Find (Gibson & Lyons, 1998b). *H. pendens* was previously only known from the top of Mt Caudan and the nearby ridges that contained large gossanous caps, but has since been found to be much more widespread, where Gibson & Lyons (1998b) identified 15 new populations. It was also recorded within the Jilbadji Nature Reserve. *H. pendens* was often found dominating the shrub-layer where *Allocasuarina campestris*, *A. acutivalvis*, *Eucalyptus capillosa* subsp. *polyclada* or *Eucalyptus loxophleba* dominated the upper strata (Gibson & Lyons, 1998b).

H. pendens is a tall shrub that grows between 2-3 m high and around 2.5 – 3.1 m wide. *H. pendens* is a distinct species of its group as it has a conical-shaped pollen presenter. The flowers are pink and appear as drooping tubes or 'umbels', whilst the extending pollen presenters are cream coloured. Flowering is mostly recorded in September, but it is likely to start from August and continue into October (Barker, 1990). The pinkness of the flowers develops after the release of the pollen presenter, so early flowering specimens would appear white (Barker, 1990).

The species was highly common (2,100 individuals across 545 locations) as recorded by Botanica. Botanica located the species in four vegetation types, some of which contained *H. pendens* as the dominant taxa in the shrub layer. *H. pendens* was recorded in four floristic communities:

1. Low open woodland of *Eucalyptus salmonophloia* over mixed shrubs on clay-loam plain;
2. Mid-mallee shrubland of *Eucalyptus* spp. over mid shrubland of *Melaleuca pauperiflora* and mixed low shrubland on clay-loam plain;
3. Regrowth mid open mallee woodland *Eucalyptus livida* over mid open shrubland of *Hakea pendens* and open low shrubland of *Goodia medicaginea* on hillslope; and
4. Regrowth mixed low shrubland on hillslope.

Microcybe sp. Windy Hill (G.F. Craig 6583) (P3)

Microcybe sp. Windy Hill (G.F. Craig 6583) is known from the Bremer Range, Lake Medcalf and Jilbadji areas. It has been recorded flowering in May, September to October, and December (DBCA, 2018c).

Little information is available for this species, however, a potentially similar species named *M. sp.* Hatter Hill (K.R.Newbey 6546), has been described in the WA Wildlife Management Programme no. 21 (Craig, & Coates, 2001). This species was supposedly known only from the Hatter Hill area, occurring on a small kaolinitic breakaway in well-drained loam. Its habit is described as a spreading, moderately dense, woody shrub reaching 50 - 70 cm tall and 40 - 50 cm wide. The flowers are without stalks, growing as terminal heads, with the linear leaves extending beyond the head. This description is very similar when crossed against the photograph provided by

Botanica. *M.* sp. Hatter Hill is defined as being affiliated with *M. pauciflora*. Unfortunately, no information is publically available to attest whether *M.* sp. *Hatter Hill* has been assigned a formal name.

Botanica identified 620 individuals of *M.* sp. Windy Hill (G.F. Craig 6583) in two floristic communities:

1. Mid mallee shrubland of Eucalyptus spp. over mid shrubland of Melaleuca pauperiflora and mixed low shrubland on clay-loam plain, and
2. Regrowth mixed low shrubland on hillslope.

Teucrium diabolicum (previously Teucrium sp. dwarf (R. Davis 8813) (P3))

This taxon has been recently formally named as *Teucrium diabolicum*, which is not listed as a Priority Flora species on Florabase. Botanica were unable to confirm whether or not this taxon is a Priority Flora at the time of this ERD preparation. As such the assessment in this ERD assumes that the original Priority 3 rating remains.

Teucrium is a genus of half-shrubs, perennial herbs and rarely, dwarf-shrubs. They are recognisable by their distinctive flower morphology: the stamen and stigma of these plants protrude and are angled to aid in brushing its pollinator (Navarro, Oualidi, & Trigo, 2004).

Teucrium diabolicum is described as a small herb growing only between 0.1 - 0.2 m tall. A specimen collected in 2012 was located within a shallow depression in mixed low heath with regenerating Eucalyptus woodland. The soil was described as crumbling red loamy-clay. A total of 200 plants in a 10 cm diameter were recorded as the frequency of occurrence for the plant. *T.* sp. dwarf is known to flower in April, with flowers that are white or cream in colour (Lucid, 2019).

Teucrium diabolicum is commonly found on road verges, hillslopes and plains (Botanica, 2017a), which suggests it may be responsive to temporary pooling / flooding in clay depressions, with growth triggered by rainfall events (Toelken, 1985). Botanica recorded 11,200 individuals of this species within five vegetation types:

a. Low open woodland of *Eucalyptus salmonophloia*, over mixed shrubs on clay-loam plain;
b. Mid-mallee shrubland of Eucalyptus spp. over mid-shrubland of *Melaleuca pauperiflora* and mixed low shrubland on clay-loam plain;
c. Mid open mallee woodland of *Eucalyptus livida* over heathland of *Allocasuarina / Hakea / Melaleuca* an open low sedge of *Lepidosperma sanguinolentum* on hillslope;
d. Regrowth mixed low shrubland on hillslope; and
e. Regrowth low open woodland of *Codonocarpus cotinifolius* over mid shrubland of *Acacia/Melaleuca* spp. and open tussock grassland of *Schoenus breviculmis* on sand-loam plain.

Germination Trials

Seed quality measurements for three seed collections for *H. pendens* and *E. rhomboidea* submitted for assessment by DBCA are presented in Table 25. The collection of *H. pendens* had high purity and high germination.

The purity of the two samples of *E. rhomboidea* was low (<20%). Low purity is not unusual for eucalypt collections where it can be difficult to separate seed from chaff and non-seed material, however there was a considerable amount of non-seed material including soil that could be simply removed using sieves. Seed of *E. rhomboidea* was readily distinguishable from other material in the samples.

Table 25: Seed quality characteristics of *Hakea pendens* and *Eucalyptus rhomboidea* seed collections

Species Name		***Hakea pendens***	***Eucalyptus rhomboidea***	
Initial collection weight (g)		11.7	4.5	212.5
Collection dry weight (g)		11.6	4.3	211.5
SAMPLE	**Weight/seed (g)**	1.45 x10^{-2}	6.82 x10^{-3}	3.02 x10^{-2}
	Seed per g	68	147	33
	Purity (%)	79.5	17.4	2.8
PURE	**Weight/seed (g)**	1.18 x 10^{-2}	1.18 x 10^{-3}	8.35 x 10^{-4}
	Seed per g	85	845	1198
Seed in collection (* estimated)		781	630	6,997*
cut test		NA	NA	NA
Germination (% ± S.E.) (# ongoing)		99 ± 1	15°C: 11 ± 2 20°C: 18 ± 6#	15°C: 3 ± 1 20°C: 12 ± 4#
Tetrazolium viability (%)		NA	100	96

Botanica (2020b) has suggested that no further collections of the *H. pendens* seed is required as this species is able to germinate readily. Further collections of *E. rhomboidea* and *S. bremerense* seed will need to be carried out, ideally in late spring as it would be beneficial for Audalia to work closely with the Threatened Flora Seed Centre to ensure that collections meet their standards.

5.3.8 Introduced Flora (Weeds)

Nine introduced taxa were identified within the mine study area, with none identified within the haul road study area (Botanica, 2020c). None of these taxa were considered Weeds of National Significance or Declared plants under the *Biosecurity and Agriculture Management Act 2007* (BAM Act). A description of the invasive flora of the study areas and their legal status' are provided below.

Asphodelus fistulosus (Onion Weed)

Onion Weed is described as an annual or biennial herb growing between 0.2 - 0.4 m high. It produces white flowers from June to October. It occupies sand, clay and calcareous soils. Botanica identified this species within the floristic community; Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain.

Bromus rubens (Red brome)

Red brome is described as a tufted annual and grass-like or herb. It grows between 0.1 - 0.4 m in height and produces green to red-purple flowers from August to October. It occupies sand, red-brown clay and calcareous loam soils. Botanica located this species within the floristic community; Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain.

***Carrichtera annua* (Ward's Weed)**

Ward's Weed is an erect, annual herb that grows between 0.05 - 0.4 m tall. It produces yellow flowers from September to November and occupies semi-arid regions. This species was located within two floristic communities:

1. Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain; and
2. Regrowth mixed low shrubland on hillslope.

***Centaurea melitensis* (Maltese cockspur)**

The Maltese Cockspur is an erect, annual or biennial herb that grows between 0.2 - 1 m tall. It produces yellow flowers from September - December or from January - March. It commonly occupies disturbed areas specifically along roadsides and cultivated areas. Botanica recorded this species within two floristic communities:

1. Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain; and
2. Regrowth mixed low shrubland on hillslope.

***Lysimachia arvensis* (Pimpernel)**

Pimpernel is a prostrate annual or perennial forb, with two varietals, one with bright blue flowers or one with bright orange to red flowers. The blue variety is usually more robust. Flowers are about 1 cm across, and appear in the spring months (Urban Bushland Council WA Inc, 2019). Botanica recorded this species in the Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain floristic community.

***Pentameris airoides* (False Hairgrass)**

This species is described as an annual or perennial grass that is widespread in the temperate southern half of Australia. It flowers between August and December (Aus Grass2, 2010). Botanica recorded this species within the Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain floristic community.

***Rostraria pumila* (Roughtail)**

The Roughtail is described as a tufted annual, grass-like or herb, that grows between 0.05 - 0.2 m high. It produces green flowers from July to October. It occupies grey, black or red sand, sandy clay, clay, and limestone on roadsides, sand dunes and cliff slopes. Botanica recorded this species within the Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain floristic community.

***Sonchus oleraceus* (Common sowthistle)**

Common sowthistle is an erect, annual herb that grows from 0.30 - 1.5 m high. It is typically winter dominant, and occupies a variety of soils, often in waste places and disturbed ground. It flowers yellow sometimes all year round depending on conditions. Botanica recorded this species within four floristic communities:

1. Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain;
2. Mid-mallee shrubland of *Eucalyptus* spp. over mid shrubland of *Melaleuca pauperiflora* and mixed low shrubland on clay-loam plain;
3. Regrowth of low open forest of *Eucalyptus* sp. (Sterile) on hillslope; and
4. Regrowth mixed low shrubland on hillslope.

Vulpia muralis

Vulpia muralis is described as a slender annual, grass-like or herb that grows 6 – 60 cm high. It flowers between August to December, sometimes May to August, and fruits occur in September to November. It occurs in moist or dry and open habitats. Botanica recorded this species in one floristic community; Low open woodland of *E. salmonophloia* over mixed shrubs on clay-loam plain.

5.3.9 Vegetation

Floristic Communities

Fourteen floristic communities were identified within the survey area. These communities were located within five different landform types and comprised of five major vegetation groups, which were represented by a total of 58 Families, 162 Genera and 411 Taxa. A summary of floristic communities is provided in Table 26 and shown in Figure 40 to Figure 45.

Table 26: Summary of floristic communities within the survey area

Landform	NVIS Vegetation Group	Floristic Community[1]	Vegetation Code	Area (ha)	Area (%)
Closed Depression	Chenopod Shrublands, Samphire Shrublands and Forblands (MVG 22)	Low samphire shrubland of *Tecticornia indica* subsp. *bidens* over low open forbland of *Disphyma crassifolium* on playa	CD-CSSSF1	67	0.4
Clay-Loam Plain	Eucalypt Woodlands (MVG 5)	Low open woodland of *Eucalyptus salmonophloia* over mixed shrubs on clay-loam plain	CLP-EW1	10,022[2]	53.4
	Mallee Woodlands and Shrublands (MVG 14)	Mid mallee shrubland of *Eucalyptus* spp. over mid shrubland of *Melaleuca pauperiflora* and mixed low shrubland on clay-loam plain	CLP-MWS1	1,975	10.5
		Mid mallee woodland of *Eucalyptus* spp. over mixed low shrubland / heathland on clay-loam plain	CLP-MWS2	2,561	13.6
Granite Outcrop	Heathlands (MVG 18)	Heathland of *Thryptomene* spp. over sparse tussock grassland of *Neurachne alopecuroidea* on granite outcrop	G-H1	265	1.4
Hillslope	Eucalypt Woodlands (MVG 5)	Regrowth of low open forest of *Eucalyptus* sp. (Sterile) on hillslope	HS-EW1	15	0.1
	Mallee Woodlands and Shrublands (MVG 14)	Regrowth mid open mallee woodland of *Eucalyptus livida* over mid open shrubland of *Hakea pendens* and open low shrubland of *Goodia medicaginea* on hillslope	HS-MWS1	150	0.8
		Regrowth low open mallee shrubland of *Eucalyptus* spp. over low shrubland of *Acacia* spp. and open tussock grassland of *Schoenus breviculmis* on hillslope	HS-MWS2	16	0.1
		Mid open mallee woodland of *Eucalyptus livida* over heathland of *Allocasuarina* / *Hakea* / *Melaleuca* and open low sedge of *Lepidosperma sanguinolentum* on hillslope	HS-MWS3	96	0.5

Landform	NVIS Vegetation Group	Floristic Community[1]	Vegetation Code	Area (ha)	Area (%)
	Other Shrublands (MVG 17)	Regrowth mixed low shrubland on hillslope	HS-OS1	412	2.2
Sand-Loam Plain	Eucalypt Woodlands (MVG 5)	Low woodland of *Eucalyptus salicola* over low open shrubland of *Phebalium filifolium* and low open sedgeland of *Gahnia ancistrocarpa* on sand-loam plain	SLP-EW1	1,519	8.1
	Mallee Woodlands and Shrublands (MVG 14)	Mid sparse mallee shrubland of *Eucalyptus eremophila* over heathland of *Melaleuca* spp. on sand-loam plain	SLP-MWS1	1,436	7.74
		Regrowth mid sparse mallee shrubland of *Eucalyptus* spp. over low open shrubland of *Acacia* / *Grevillea* spp. and open hummock grassland of *Triodia scariosa* on sand-loam plain	SLP-MWS2	67	0.4
	Other Shrublands (MVG 17)	Regrowth low open woodland of *Codonocarpus cotinifolius* over mid shrubland of *Acacia* / *Melaleuca* spp. and open tussock grassland of *Schoenus breviculmis* on sand-loam plain	SLP-OS1	27	0.1
TOTAL				**18,770**	**100**

[1] Descriptions of floristic communities are based on the vegetation structure at the time of survey (2014 - 2015 and 2017). Vegetation structure of regrowth vegetation types is subject to change with continued recovery from fire.

[2] 5,381 ha comprised of mature woodland. Remaining area comprised of regrowth.

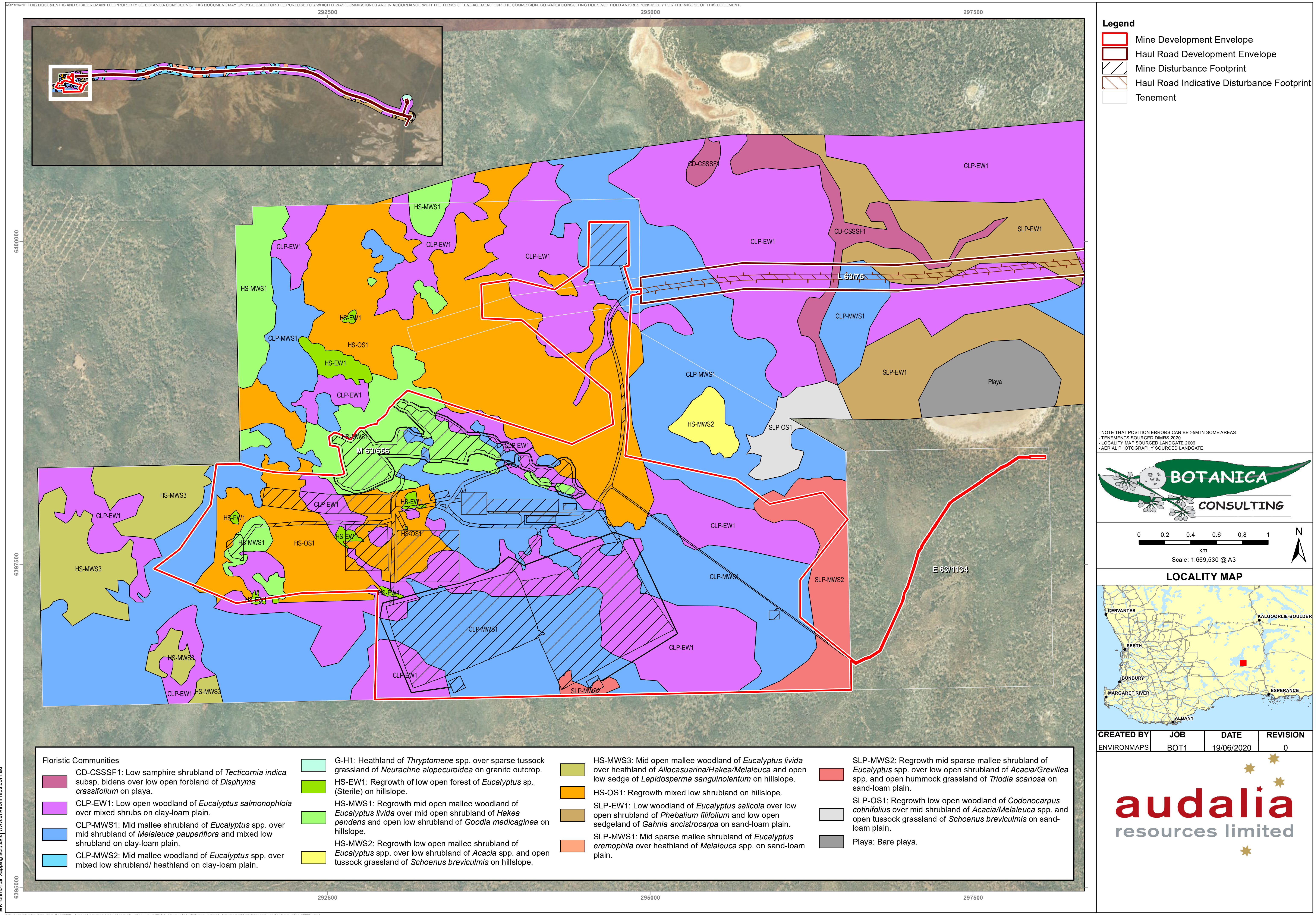


Figure 40: Floristic Communities (1 of 6)

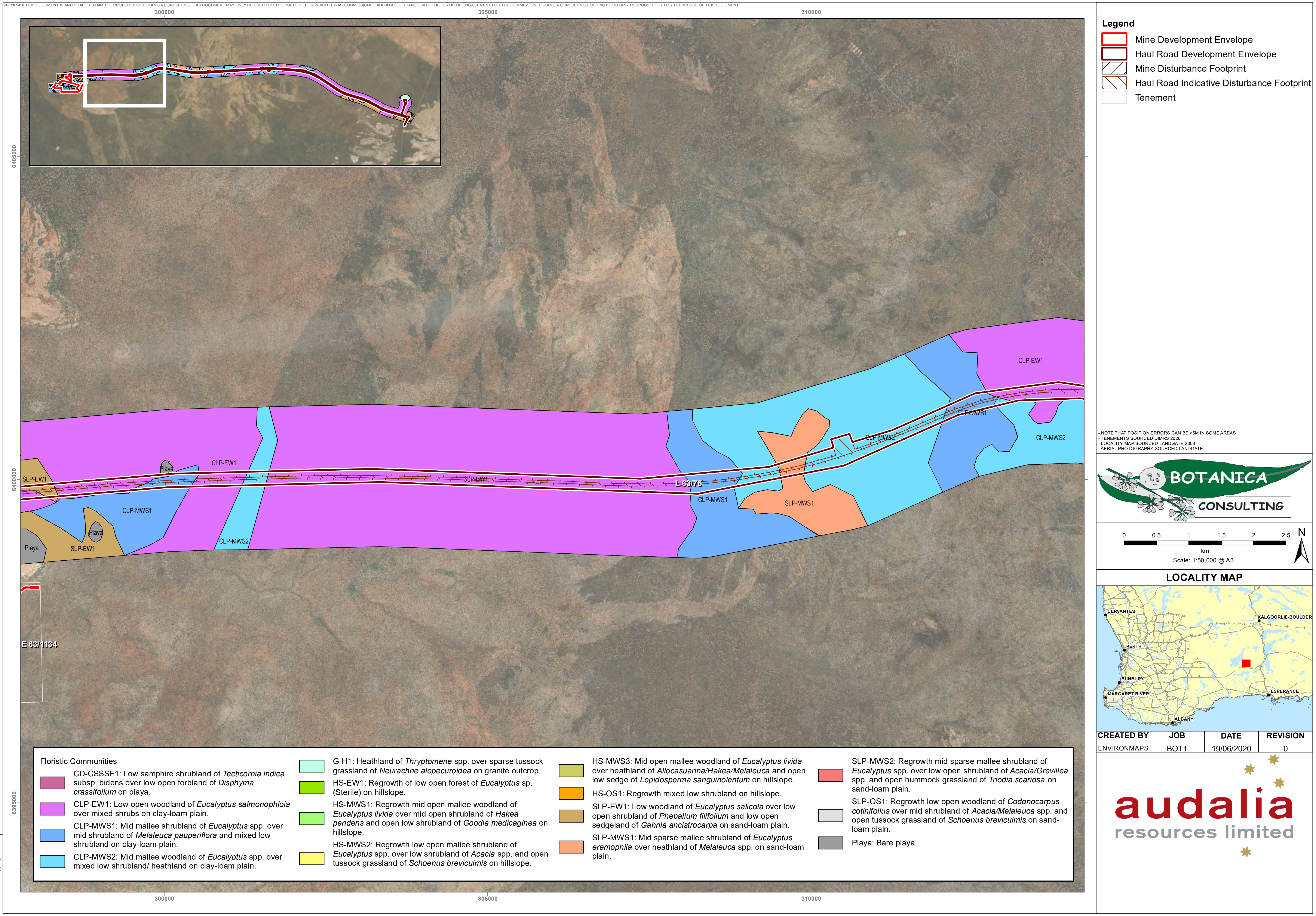


Figure 41: Floristic Communities (2 of 6)

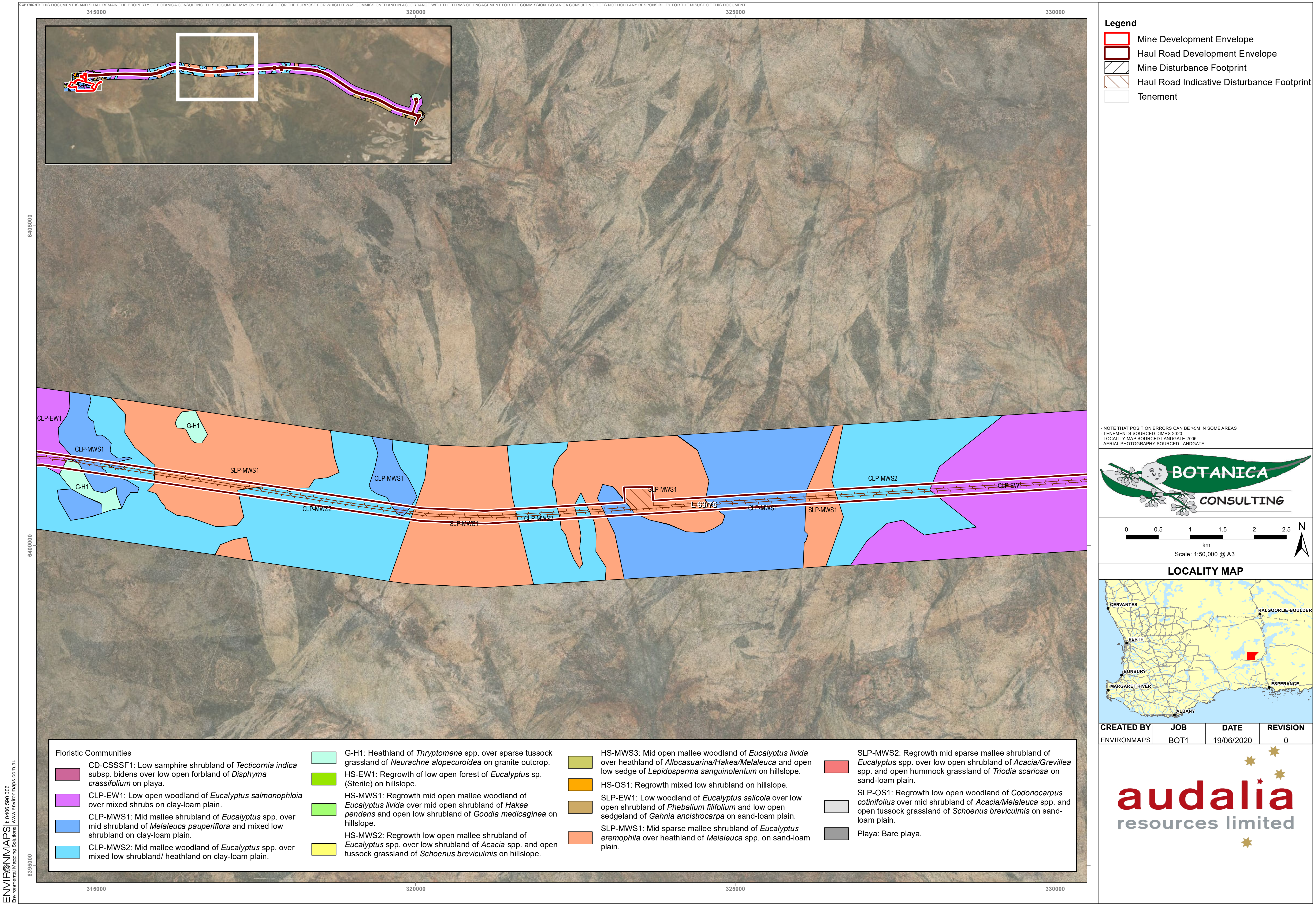


Figure 42: Floristic Communities (3 of 6)

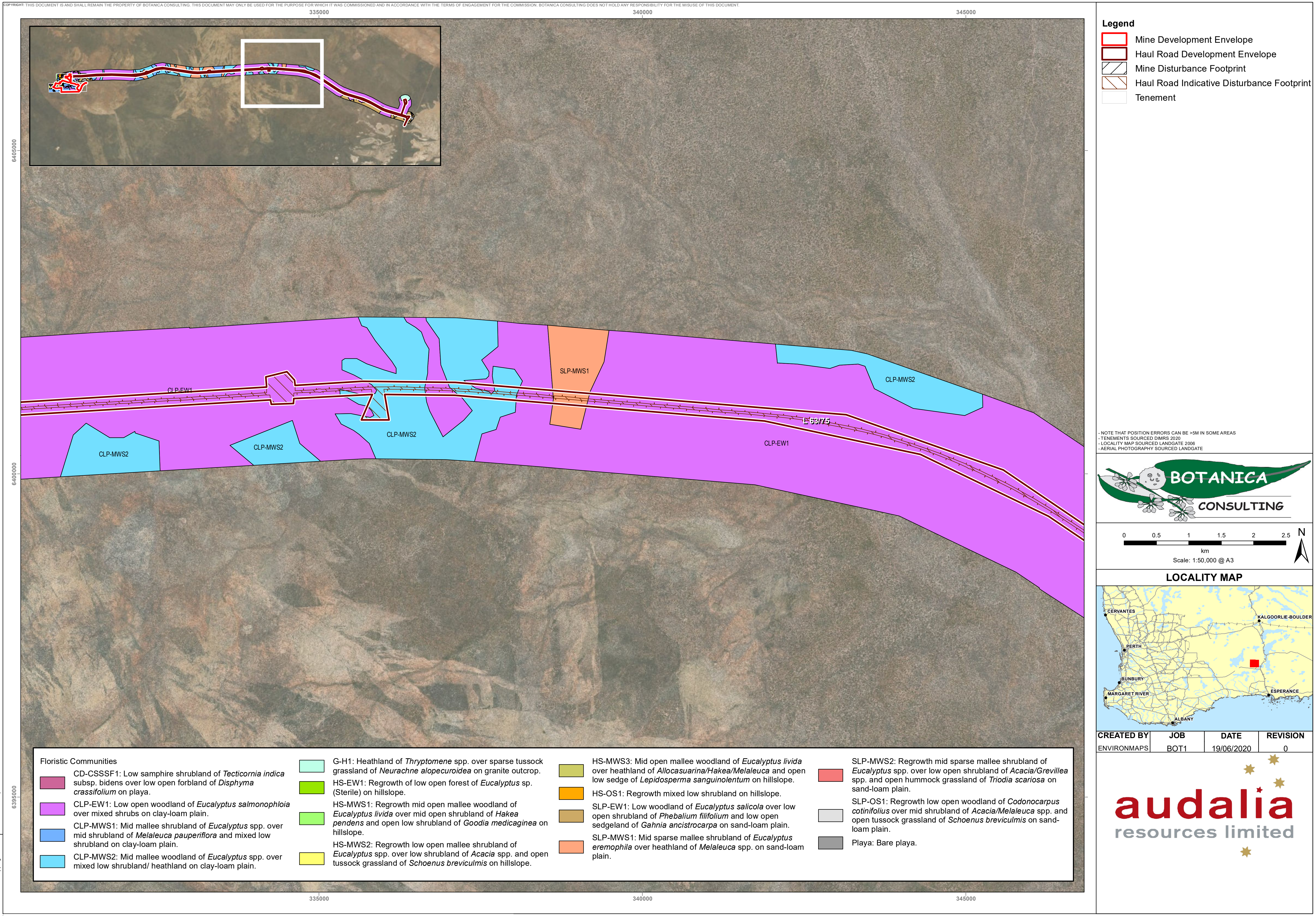


Figure 43: Floristic Communities (4 of 6)

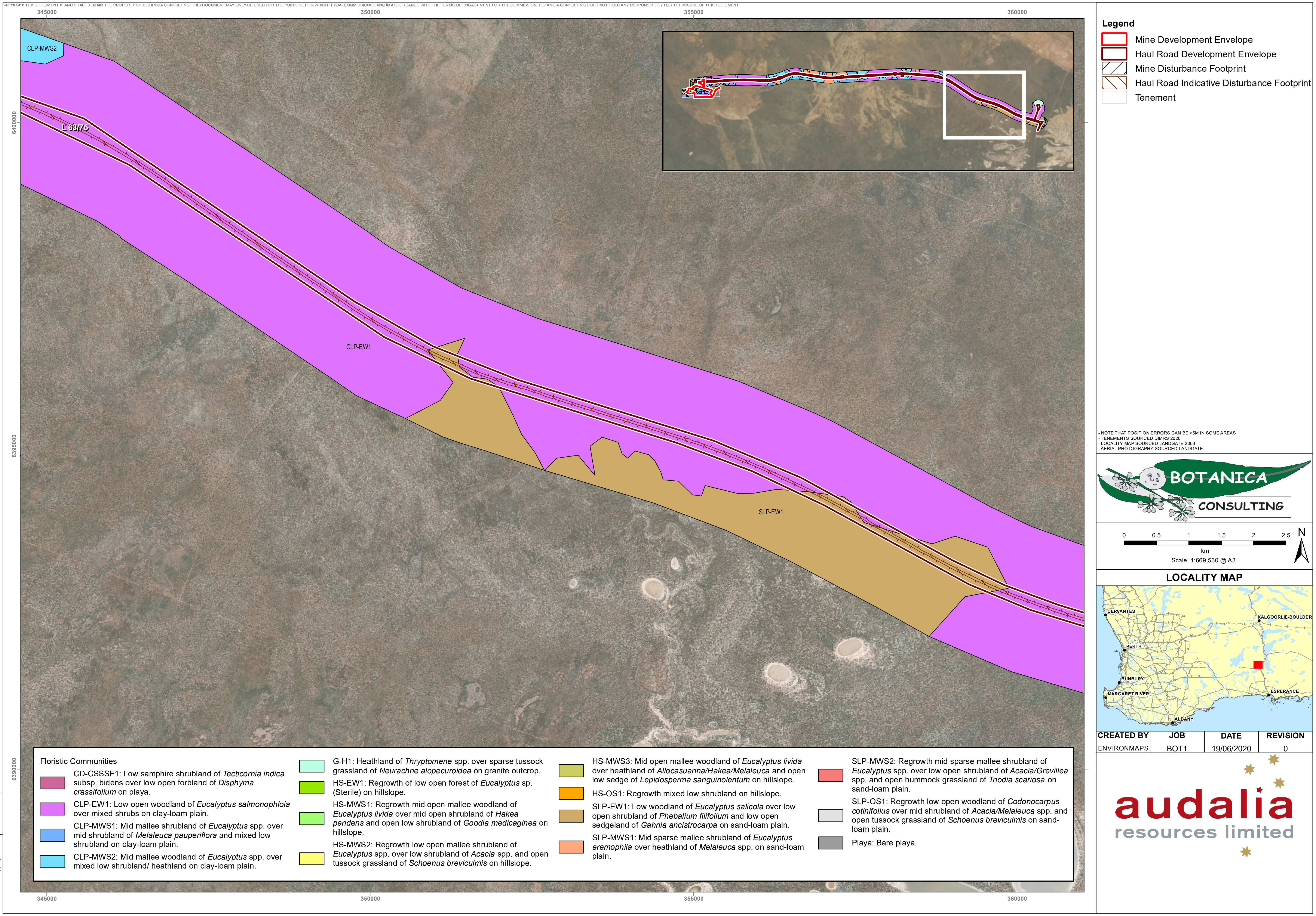


Figure 44: Floristic Communities (5 of 6)

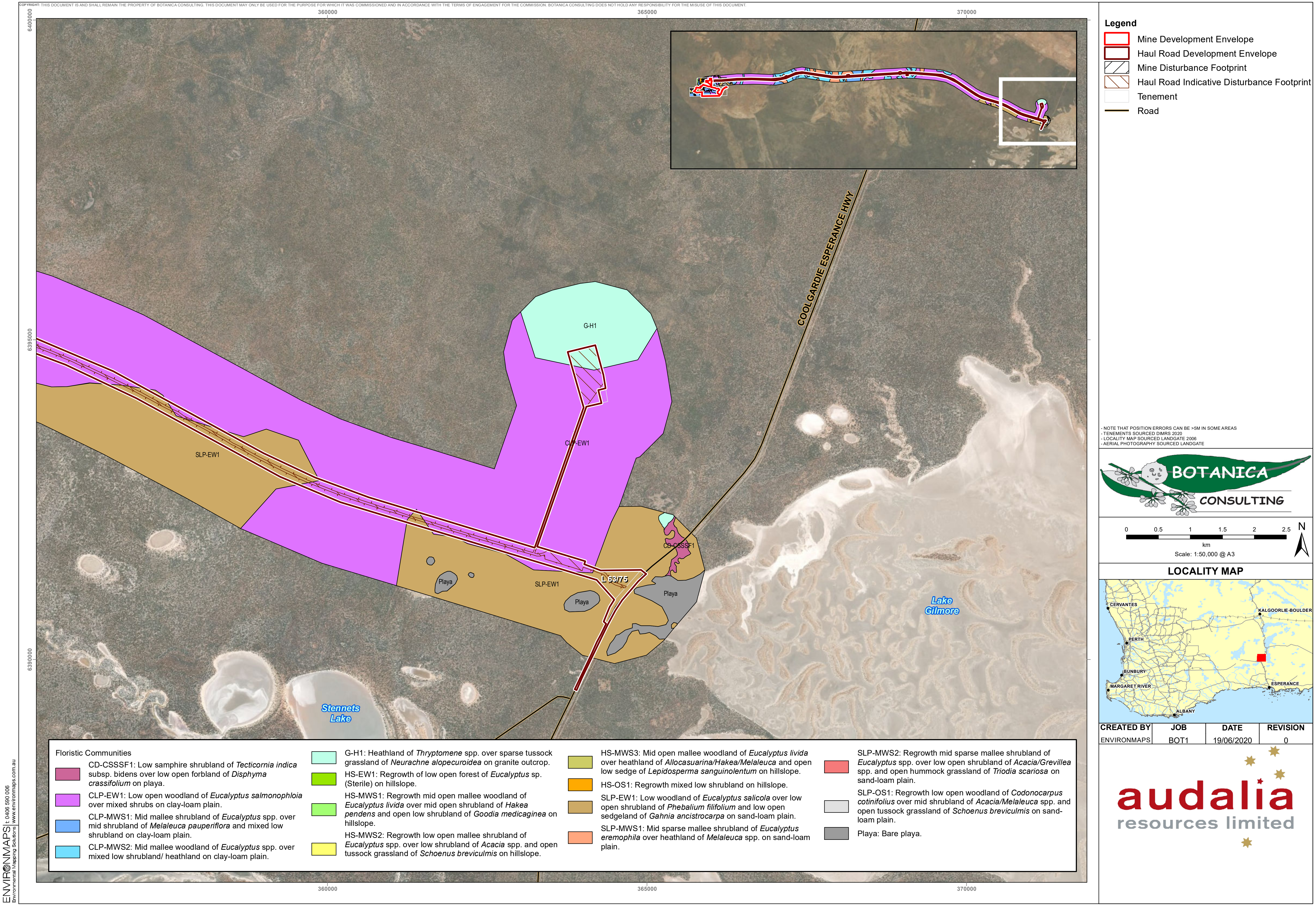


Figure 45: Floristic Communities (6 of 6)

Vegetation Condition

Based on the vegetation condition rating scale adapted from Keighery (1994) and Trudgen (1991), eight floristic communities were rated as 'good' and the remaining seven communities had a vegetation condition rating of 'very good' (Table 27). A map of the vegetation condition within the survey area is provided in Figure 46.

'Good' condition depicts that vegetation structure has been significantly altered by very obvious signs of multiple disturbances, however it retains its basic vegetation structure or has ability to regenerate it. There is some disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.

'Very Good' condition depicts that vegetation structure has been altered by obvious signs of disturbance, caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.

The survey area has been subjected to a major fire in 2010 (Figure 47), with some areas subjected to multiple successional fires in 2010 (not available on Landgate database). In February 2015, the area was again subjected to fire (observed by Audalia staff in the area) however this fire has not been recorded on the Landgate database. In 2019, fires occurred directly west of the survey area within the Honman Ridge area. Vegetation within the survey area and surrounding region is therefore in various stages of regrowth.

Table 27: Vegetation condition rating of the survey area

Vegetation Code	Floristic Community	Vegetation Condition
CD-CSSSF1	Low samphire shrubland of *Tecticornia indica* subsp. *bidens* over low open forbland of *Disphyma crassifolium* on playa	Very Good
PLAYA	Playa (no vegetation)	N/A
CLP-EW1	Low open woodland of *Eucalyptus salmonophloia* over mixed shrubs on clay-loam plain	Good
CLP-MWS1	Mid mallee shrubland of *Eucalyptus* spp. over mid shrubland of *Melaleuca pauperiflora* and mixed low shrubland on clay-loam plain	Very Good
CLP-MWS2	Mid mallee woodland of *Eucalyptus* spp. over mixed low shrubland/heathland on clay-loam plain	Very Good
G-H1	Heathland of *Thryptomene* spp. over sparse tussock grassland of *Neurachne alopecuroidea* on granite outcrop	Very Good
HS-EW1	Regrowth of low open forest of *Eucalyptus* sp. (Sterile) on hillslope	Good
HS-MWS1	Regrowth mid open mallee woodland *Eucalyptus livida* over mid open shrubland of *Hakea pendens* and open low shrubland of *Goodia medicaginea* on hillslope	Good
HS-MWS2	Regrowth low open mallee shrubland of *Eucalyptus* spp. over low shrubland of *Acacia* spp. and open tussock grassland of *Schoenus breviculmis* on hillslope	Good
HS-MWS3	Mid open mallee woodland *Eucalyptus livida* over heathland of *Allocasuarina/Hakea/Melaleuca* and open low sedge of *Lepidosperma sanguinolentum* on hillslope	Good
HS-OS1	Regrowth mixed low shrubland on hillslope	Good
SLP-EW1	Low woodland of *Eucalyptus salicola* over low open shrubland of *Phebalium filifolium* and low open sedgeland of *Gahnia ancistrocarpa* on sand-loam plain	Very Good

Vegetation Code	Floristic Community	Vegetation Condition
SLP-MWS1	Mid sparse mallee shrubland of *Eucalyptus eremophila* over heathland of *Melaleuca* spp. on sand-loam plain	Very Good
SLP-MWS2	Regrowth mid sparse mallee shrubland of *Eucalyptus* spp. over low open shrubland of *Acacia/Grevillea* spp. and open hummock grassland of *Triodia scariosa* on sand-loam plain	Good
SLP-OS1	Regrowth low open woodland of *Codonocarpus cotinifolius* over mid shrubland of *Acacia/Melaleuca* spp. and open tussock grassland of *Schoenus breviculmis* on sand-loam plain	Good

Floristic Composition

Two 'supergroups' were identified in the PATN analysis:

1. Hillslopes (mallee woodland and shrubland), sand-loam plain (other shrubland/ eucalypt woodland / mallee woodland and shrubland), granite outcrop (other shrubland) and closed depression (chenopod/ samphire shrubland), clay-loam plain (mallee woodland and shrubland); and
2. Hillslopes (eucalypt woodland / other shrubland), clay-loam plain (eucalypt woodland / mallee woodland and shrubland), sand-loam plain (mallee woodland and shrubland).

The first supergroup was divided into eight floristic groups, comprising of quadrats from each of the five different landform types and major vegetation groups. The hillslopes communities (mallee woodland and shrubland), were divided into three groups, intermixed with quadrats from the clay-loam plain communities. The clay-loam plain communities were divided into four groups. The sand-loam plain (other shrubland / eucalypt woodland / mallee woodland and shrubland) communities were divided into four groups, also intermixed with quadrats from the clay-loam plain communities. The granite outcrop and closed depression community quadrats were grouped separately from all other quadrats.

The second group was divided into six floristic groups, comprising of quadrats from three different landform types hillslopes clay-loam plain and sand-loam plain) and three major vegetation groups (eucalypt woodland, other shrubland and mallee woodland and shrubland).

Based on the results of the PATN analysis, there was minimal heterogeneity in species composition across the survey area, with majority of vegetation types intermixed into floristic groups despite differences in both dominant stratum taxa and landform. The two super groups were highly mixed including quadrats from all the different landforms and major vegetation groups.

Legend

- Mine Development Envelope
- Haul Road Development Envelope
- Road
- Railway

Vegetation Condition

- Very Good
- Good

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- TENEMENTS SOURCED DMIRS 2020
- LOCALITY MAP SOURCED LANDGATE
- AERIAL PHOTOGRAPHY OPEN SOURCE

Preston Consulting

0 2 4 6 8 10
km
Scale: 1:250,000 @ A3
N

LOCALITY MAP

CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900035	9/07/2020	0

audalia resources limited

ENVIRONMAPS Environmental Mapping Solutions t 0406 590 006 www.environmaps.com.au

C:\GIS\Jobs\Preston Consulting\PC2900035 - Audalia Resources, Part IV Approvals ERD\F_Figures\PC2900035_Vegetation Condition_200709.mxd

Figure 46: Vegetation condition rating of the survey area

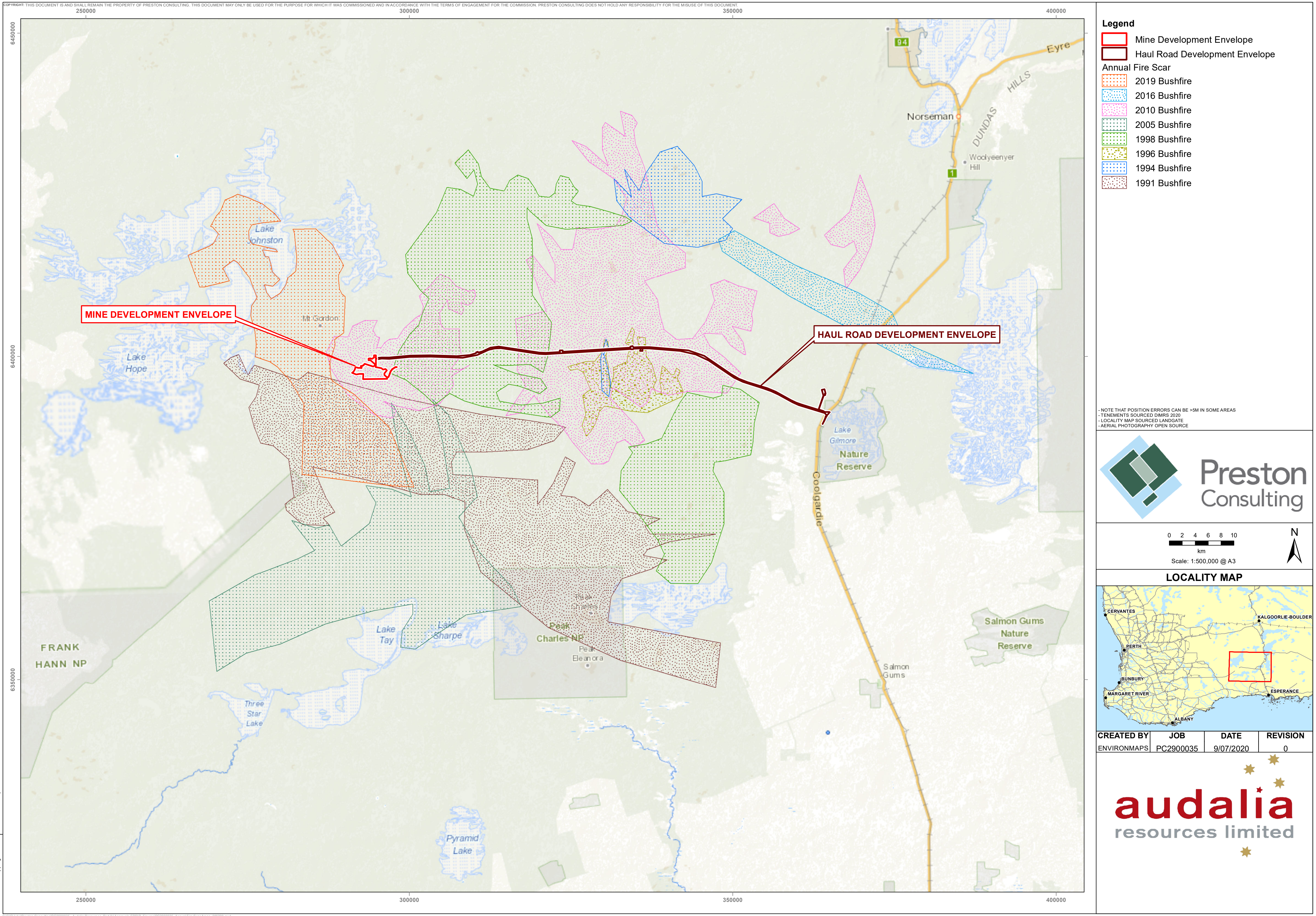


Figure 47: Map of fire history along the extent of the survey area (Landgate, 2019)

Significant Vegetation

According to the EPA Environmental Factor Guideline for Flora and Vegetation (EPA, 2016c) significant vegetation includes vegetation that:

- Is identified as TECs or PECs;
- Has a restricted distribution;
- Is subject to a high degree of historical impact from threatening processes;
- Provides a role as a refuge; and
- Provides an important function required to maintain ecological integrity of a significant ecosystem.

No TECs, restricted vegetation, highly disturbed vegetation, vegetation providing important refuge or significant ecological function was identified within the survey area. The western region of the survey area is located within the Bremer Range vegetation complexes PEC which is listed by DBCA as a Priority 1 Ecological Community. This PEC (including the 500m buffer zone) encompasses an area of 88,150 ha and is centred on Mt Day, Round Top Hill and Honman Ridge (located outside the survey area). The Bremer Range has potentially been listed as a PEC based on studies conducted by How *et. al*. (1988) and Gibson & Lyons (1998b) which identified specialised vegetation mosaics associated within the BIF of Bremer Range. A description of the Bremer Range vegetation complexes PEC provided by the DBCA (2017) is provided below:

> *"Eucalyptus rhomboidea ms* and *E. eremophila woodland* on the side slopes of low ridges*; E. flocktoniae woodland* (with *E. salubris, E. salmonophloia, E. dundasii* and *E. tenuis*) on broad flat ridges and side slopes*; E. flocktoniae* and / or *E. longicornis* woodland on saline soils on ridges and flats adjacent to large salt lake systems*; E. longicornis* and / or *E. salmonophloia* or, *E. georgei* subsp. *georgei* or, *E. dundasii* woodland, on low areas; *E. livida* woodland on lateritic tops or *Allocasuarina* thickets on greenstone ridges of lateritic breakaways; *Acacia duriuscula, Allocasuarina globosa, E. georgei subsp. georgei* and *E. oleosa* thickets on greenstone ridges with skeletal soils."

The lateritic hillslopes of the Medcalf deposit and lateritic hillslopes within the greater Bremer Range studied by Gibson & Lyons (Community 5) were grouped together, indicating the lateritic hillslopes of the Medcalf area have a similar species composition of lateritic hillslopes within the greater Bremer Range PEC. The Eucalypt woodland and Mallee woodland vegetation types within the Bremer Range region were also representative of the Bremer Range PEC.

The granite outcrop, closed depression community and Eucalypt woodlands associated with sand-loam plains community which were located along the haul road survey area were not represented within the Bremer Range PEC.

The *Allocasuarina globosa* assemblages on greenstone rock PEC was also located approximately 3.5 km south-west of the survey area, and is listed by DBCA as a Priority 1 Ecological Community. These assemblages are only known from the Norseman area and in the Bremer Ranges. None of the floristic communities within the survey area are representative of this PEC.

Botanica (2020c; Appendix 3.9) provides a detailed comparison of the Botanica quadrats and the Gibson & Lyon quadrats (1998b).

Locally Significant Vegetation

Eight floristic communities are considered to be significant vegetation as they resemble the floristic values of the Bremer Range Vegetation Complexes PEC. One of these (HS-MWS1) is also significant as it provides habitat for *M. aquilonaris*.

Table 28 summarises the extent of the locally significant vegetation within the survey area. The extent of this locally significant vegetation is shown on Figure 48.

Table 28: Locally significant vegetation

Floristic Community Unit	Reason for significance	Extent in survey area (ha)	Extent in DEs (ha)
CLP-EW1	Vegetation representative of the Bremer Range Vegetation Complexes PEC	10,022	1,237
CLP-MWS1		1,975	464
CLP-MWS2		2,561	234
HS-EW1		15	5
HS-MWS1	Vegetation representative of the Bremer Range Vegetation Complexes PEC, Provides habitat for *M. aquilonaris* (T)	150	63
HS-MWS2	Vegetation representative of the Bremer Range Vegetation Complexes PEC	16	0
HS-MWS3		96	0
HS-OS1		412	167

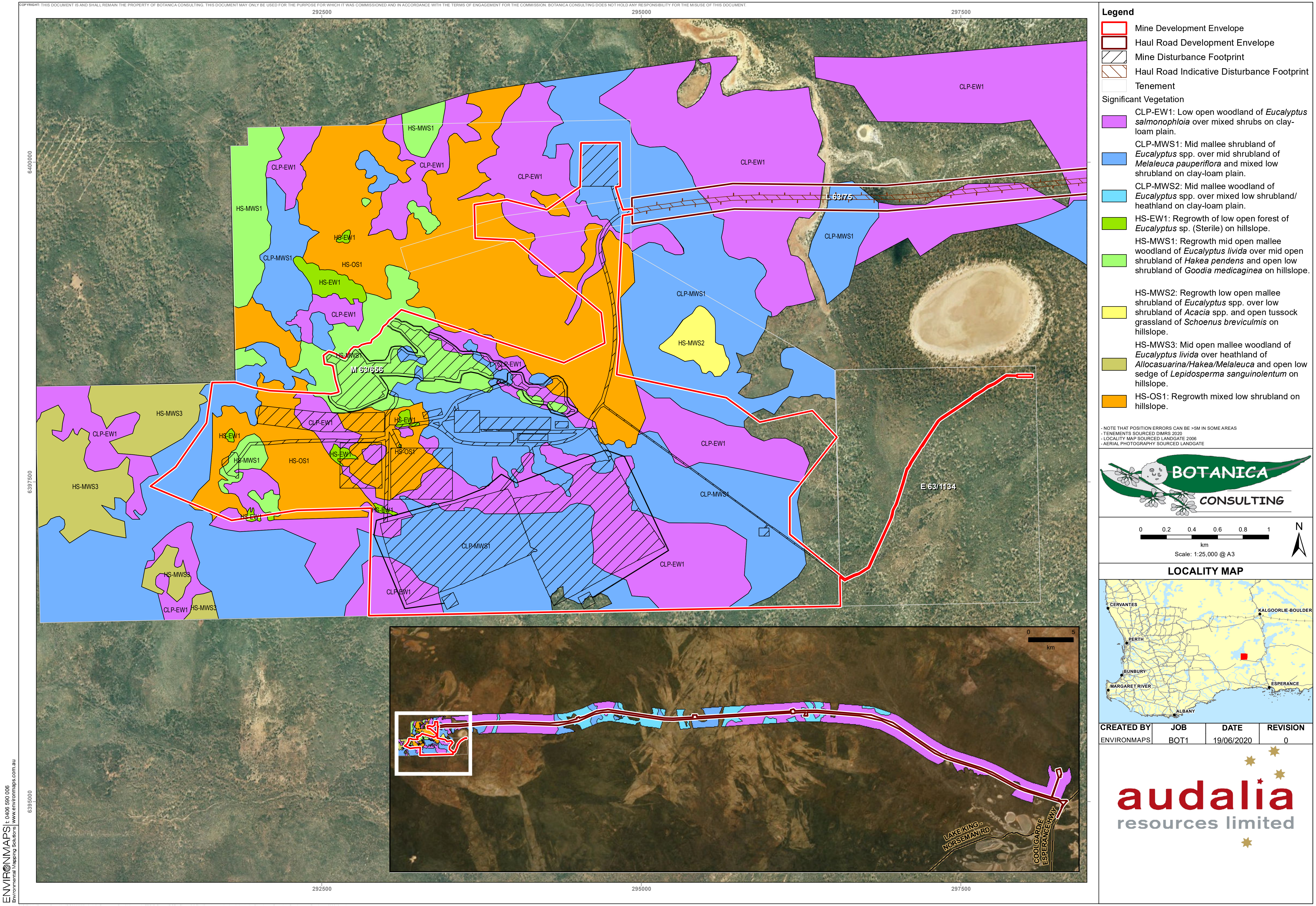


Figure 48: Locally significant vegetation

5.3.10 Environmental Values

The information provided in Section 5.3 was utilised to determine the environmental values that require assessment for this factor. Values were included for assessment based on the following parameters from EPA (2016c):

Flora:

- Being identified as threatened or priority species;
- Locally endemic or associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- New species or anomalous features that indicate a potential new species;
- Representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; or
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Vegetation:

- Being identified as threatened or priority ecological communities;
- Restricted distribution;
- Degree of historical impact from threatening processes;
- A role as a refuge; or
- Providing an important function required to maintain ecological integrity of a significant ecosystem.

Based on the parameters listed above, the following environmental values were determined to require assessment for this factor:

1. General flora and vegetation;
2. *M. aquilonaris* (T);
3. *Eucalyptus rhomboidea* (P4);
4. *Stenanthemum bremerense* (P4);
5. Other Priority Flora;
6. The proposed Bremer Range Nature Reserve;
7. The Bremer Range Vegetation Complexes PEC; and
8. Locally significant vegetation.

5.4 Potential Impacts

Table 29 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context.

Table 29: Potential impacts to flora and vegetation

Environmental value	Current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General flora and vegetation	The pre-European vegetation associations within the survey area are relatively uncleared with a minimum of 97% of each type remaining The majority of vegetation within the study area is currently in a state of regeneration after a series of fires in 2009/2010	Up to 650 ha clearing of vegetation, which lies within the Great Western Woodlands region and within the 'pathway' of the Gondwanalink project, including associated fragmentation impacts	Reduction in vegetation health as a result of: • Excessive dust • Changes to hydrological regimes • Hydrocarbon or saline water spills • Establishment or spread of weed species / populations • Increased fire risks	No other proposals are located in proximity to the Proposal.	Up to 650 ha of direct disturbance and fragmentation Some indirect vegetation health impacts
M. aquilonaris (T)	Known from five sub-populations which occur within the Bremer Range. 14,627 plants are listed on the TPFL database (DPaW, 2017)	No direct disturbance of current sub-populations or optimal habitat	Disturbance of 1.51 ha of sub-optimal habitat within the critical habitat boundary Disturbance of sub-population 1f which has a single historic record Reduction in flora and/or habitat health as a result of: • Excessive dust • Changes to microclimate • Changes to hydrological regimes • Hydrocarbon or saline water spills • Unauthorised access • Establishment or spread of weed species / populations • Increased fire risk Disturbance and indirect impacts to pollinator habitat	No other proposals are currently impacting this value	Disturbance of 1.51 ha of sub-optimal habitat within the critical habitat boundary Disturbance of sub-population 1f which has a single historic record Reduction in flora and/or habitat health as a result of indirect impacts Disturbance and indirect impacts to pollinator habitat
E. rhomboidea (P4)	268 locations of this taxon have been recorded from six sub-populations (15,606 individuals including Botanica and DBCA records). This taxon is endemic to the Bremer Range area.	Disturbance of: • 768 individuals • 0.4 ha of sub-population extent • 77 ha of optimal habitat • 205 ha of sub-optimal habitat	Reduction in flora and/or habitat health as a result of: • Excessive dust • Changes to hydrological regimes • Hydrocarbon or saline water spills • Establishment or spread of weed species / populations	No other proposals are known to be currently impacting this value	Disturbance of: • 768 individuals • 0.4 ha of sub-population extent • 77 ha of optimal habitat • 205 ha of sub-

Environmental value	Current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
			• Increased fire risk		optimal habitat Reduction in flora and/or habitat health as a result of indirect impacts
S. bremerense (P4)	1,315 locations of this taxon were recorded from multiple populations (35,823 individuals) within the Bremer Range. 34 records of this taxon are listed on the DBCA database (4,303 individuals) extending 100 km north/ north-west of the Proposal.	Disturbance of: • 2,049 individuals • 21 ha of population extent • 263 ha of optimal habitat • 19 ha of sub-optimal habitat	Reduction in flora and/or habitat health as a result of: • Excessive dust • Changes to hydrological regimes • Hydrocarbon or saline water spills • Establishment or spread of weed species / populations • Increased fire risk	300 individuals predicted to have been disturbed at Emily Ann / Maggie Hays mines.	Disturbance of: • 2,049 individuals • 21 ha of population extent • 263 ha of optimal habitat • 19 ha of sub-optimal habitat Reduction in flora and/or habitat health as a result of indirect impacts
Other Priority Flora	Five other Priority Flora occur within the DE's; *Acacia mutabilis* subsp. *Stipulifera* (P3), *Eucalyptus pterocarpa* (P3), *Hakea pendens* (P3), *Microcybe* sp. Windy Hill (G.F. Craig 6583) (P3), *Teucrium diabolicum* (P3)	Disturbance of: • 10,001 *Acacia mutabilis* subsp. *stipulifera* individuals • 876 *Hakea pendens* individuals • 1,150 *Teucrium diabolicum* individuals	Reduction in flora and/or habitat health as a result of: • Excessive dust • Changes to hydrological regimes • Hydrocarbon or saline water spills • Establishment or spread of weed species / populations • Increased fire risk	The Emily Ann / Maggie Hays mines are predicted to have disturbed 20 *Acacia mutabilis* subsp. *Stipulifera* and 20 *Hakea pendens* individuals	Disturbance of: • 10,001 *Acacia mutabilis* subsp. *Stipulifera* individuals • 876 *Hakea pendens* individual • 1,150 *Teucrium diabolicum* individuals Reduction in flora and/or habitat health as a result of indirect impacts
Proposed Bremer Range Nature Reserve	50,920 ha, centred on the Bremer Range	Up to 309 ha of disturbance	Reduction in vegetation health as a result of: • Excessive dust • Changes to hydrological regimes • Hydrocarbon or saline water spills • Establishment or spread of weed	No other proposals lie within this proposed Nature Reserve	Up to 309 ha of disturbance Reduction in vegetation health as a result of indirect impacts

Environmental value	Current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
			species / populations • Increased fire risks		
Bremer Range Vegetation Complexes PEC	The PEC (including the 500m buffer zone) encompasses an area of 88,150 ha and is centred on Mt Day, Round Top Hill and Honman Ridge (all located outside the DEs)	285 ha of disturbance	Reduction in PEC health as a result of: • Excessive dust • Changes to hydrological regimes • Hydrocarbon or saline water spills • Establishment or spread of weed species / populations • Increased fire risks	The Emily Ann / Maggie Hays mines are predicted to have disturbed 202 ha of this PEC	487 ha of disturbance Reduction in PEC health as a result of indirect impacts
Locally significant vegetation	Eight floristic communities occur within the Bremer Range PEC and are considered to be significant vegetation, covering an area of 15,247 ha. One also provides habitat for *M. aquilonaris* (T)	544 ha of disturbance across five of the locally significant floristic communities	Reduction in vegetation health as a result of: • Excessive dust • Changes to hydrological regimes • Hydrocarbon or saline water spills • Establishment or spread of weed species / populations • Increased fire risks	No other proposals are likely to impact these vegetation types	544 ha of disturbance across five of the locally significant floristic communities Reduction in health as a result of indirect impacts

5.5 Assessment of Impacts

5.5.1 General Flora and Vegetation

Table 30 summarises the extent of the potential direct and indirect impacts on general flora and vegetation. Additional assessments are provided in the following sections.

Indirect impacts referred to in Table 30 relate to hydrological or microclimate changes, dust deposition or pollinator disturbance and are discussed in the following sections. They have been included in Table 30 to provide an overview of the total impact extents on each flora or vegetation feature.

Table 30: Extent of potential impacts to flora and vegetation

Flora / Vegetation / Feature	Regional extent (ha / no.)	Extent in Study Area (ha / no.)	Extent in Development Envelope (ha / no.)	Extent in Disturbance Footprint (ha / no.)	Indirect Impacts (ha/ no.)	Cumulative impacts (ha / no.) (% of regional extent)
Vegetation associations						
Bremer Range 491	67,021 in COO2 sub-region	N/A	63	30	Negligible	30 (<0.04%)
Cave Hill 125	46,346 in COO2, 1,555 in COO3	N/A	2	0.2	Negligible	0.2 (0.01%)
Cave Hill 128	35,226 in COO2, 529 in COO3	N/A	17	14	Negligible	14 (0.04%)
Cave Hill 522	160,644 in COO2, 14,856 in COO3	N/A	5	1	Negligible	1 (<0.01%)
Cave Hill 936	157,639 in COO2	N/A	1,365	296	Negligible	296 (0.19%)
Cave Hill 1148	21,464 in COO2	N/A	405	90	Negligible	90 (0.42%)
Cave Hill 1413	81,472 in COO2, 6,463 in COO3	N/A	572	126	Negligible	126 (0.14%)
Binneringe 522	95,964 in COO2, 166,395 in COO3	N/A	5	1	Negligible	1 (<0.01%)
Dundas 125	56,750 in COO3	N/A	2	0.2	Negligible	0.2 (<0.01%)
Dundas 128	3,516 in COO3	N/A	17	14	Negligible	14 (0.40%)
Dundas 486	0.74 in COO2, 22,349 in COO3	N/A	464	144	Negligible	144 (0.64%)
Dundas 551	844 in COO3	N/A	17	14	Negligible	14 (1.66%)
Dundas 3106	51,602 in COO3	N/A	128	17	Negligible	17 (0.03%)
PECs						
Bremer Range Vegetation Complexes PEC (Priority 1)	88,150	N/A	886	285	Negligible	285 (0.32%)
Nature Reserves						
Proposed Bremer Range Nature Reserve	50,920	N/A	1,065	309	Negligible	309 (0.61%)

Flora / Vegetation / Feature	Regional extent (ha / no.)	Extent in Study Area (ha / no.)	Extent in Development Envelope (ha / no.)	Extent in Disturbance Footprint (ha / no.)	Indirect Impacts (ha/ no.)	Cumulative impacts (ha / no.) (% of regional extent)
Floristic communities (Botanica, 2020c)						
CD-CSSSF1	N/A	67	2.2	0.2	0	0.2 (0.3%)
CLP-EW1	N/A	10,022	1,237	279	41	320 (3.2%)
CLP-MWS1	N/A	1,975	464	144	59	203 (10.3%)
CLP-MWS2	N/A	2,561	234	54	0	54 (2.1%)
G-H1	N/A	265	17	14	0	14 (5.3%)
HS-EW1	N/A	15	5	1	1	2 (13.3%)
HS-MWS1	N/A	150	63	30	50	80 (53.3%)
HS-MWS2	N/A	16	0	0	0	0
HS-MWS3	N/A	96	0	0	0	0
HS-OS1	N/A	412	167	36	14	50 (12.1%)
SLP-EW1	N/A	1,520	128	17	9	26 (1.7%)
SLP-MWS1	N/A	1,436	135	34	0	34 (2.4%)
SLP-MWS2	N/A	67	36	2	0	2 (3.0%)
SLP-OS1	N/A	27	0	0	0	0
Threatened Flora – *M. aquilonaris*						
Individuals	14,627	14,627	0	0	6	6 (0.04%)
Area of occupancy	4.51	4.51	0	0	0.01	0.01 (0.22%)
Critical habitat	64.5	64.5	2.48	1.51	2.91	4.42 (6.85%)
Optimal habitat	16.82	16.82	0	0	0.47	0.47 (2.79%)
Sub-optimal habitat	52.57	52.57	2.48	1.51	2.44	3.95 (7.51%)
E. rhomboidea (P4)						
Individuals	15,606	5,730	1,198	768	430	1,198 (7.67%)
Populations	6	Not recorded	2	2	2	2 (33.3%)
Area of occupancy	5,200	Not recorded	1.0	0.4	0.6	1.0 (0.02%)
Critical habitat	42,775	N/A	912	282	71.8	353.8 (0.83%)
Optimal habitat	2,481	N/A	227	77	55.2	132.2 (5.33%)
Sub-optimal habitat	40,294	N/A	685	205	16.6	221.6 (0.55%)
***S. bremerense* (P4)**						
Individuals	40,126	30,211	3,455	2,049	1,379	3,428 (8.54%)
Populations	25	Not recorded	3	2	2	2 (8%)
Area of occupancy	10,000	56	27	21	6.2	27.2 (0.27%)
Critical habitat	221,008	N/A	924	284	71.8	355.8 (0.16%)

Flora / Vegetation / Feature	Regional extent (ha / no.)	Extent in Study Area (ha / no.)	Extent in Development Envelope (ha / no.)	Extent in Disturbance Footprint (ha / no.)	Indirect Impacts (ha/ no.)	Cumulative impacts (ha / no.) (% of regional extent)
Optimal habitat	23,554	N/A	818	263	71.8	334.8 (1.42%)
Sub-optimal habitat	197,454	N/A	106	19	0	19 (0.01%)
Other Priority Flora						
Acacia hystrix subsp. *Continua* (P1)	122 individuals, 1 population	100 individuals, 1 population	0	0	0	0
Acacia mutabilis subsp. *Stipulifera* (P3)	348,452 individuals, 20 populations	348,311	11,215 individuals, 3 populations	10,001 individuals, 1 population	0	10,001 individuals (2.87%) 1 population (5%)
Bossiaea flexuosa (P3)	217 individuals, 2 populations	100	0	0	0	0
Brachyloma stenolobum (P1)	560 individuals, 2 populations	500	0	0	0	0
E. pterocarpa (P4)	100 individuals, 1 population	100	0	0	0	0
H. pendens (P3)	6,783 individuals, 6 populations	2,100	1,246 individuals, 2 populations	876 individuals, 2 populations	364	1,240 individuals (18.28%) 2 populations (33.3%)
Microcybe sp. Windy Hill (G.F. Craig 6583) (P3)	26,962 individuals, 15 populations	620	20 individuals, 1 population	0	0	0
Teucrium diabolicum (P3)	16,153 individuals, 12 populations	11,200	1,450 individuals, 4 populations	1,150 individuals, 3 populations	0	1,150 individuals (7.12%) 3 populations (25%)

Direct Disturbance

The Proposal will result in the direct disturbance of up to 650 ha of vegetation. When assessing the disturbance associated with the Proposal at a regional scale, the disturbance of 650 ha of native vegetation is not expected to be significant given that all vegetation associations have more than 97.9% of their pre-European extent remaining, less than 2.1% of each of these associations lie within the DEs, and less than 1.7% of each of these will be disturbed by the Proposal. Every vegetation association will still have more than 97.9% of their pre-European extent remaining after the Proposal disturbance has been considered. The Proposal will therefore not alter the conservation status of any impacted vegetation associations. In most cases this demonstrates that the disturbance of general widespread flora and vegetation is unlikely to be significant, as large areas of suitable intact vegetation will remain. The Proposal however lies within the Great Western Woodlands and within the 'pathway' of the Gondwanalink Project, and therefore the value of the land lies in the fact that it is almost completely intact. Disturbance therefore needs to be assessed in this context.

The Great Western Woodlands is the largest remaining intact Mediterranean-climate woodland in the world and is considered to be an internationally significant area of great biological richness (DEC, 2010a). It is home to almost 300 vertebrate species and a number of threatened species (Raiter, 2016). The region also has high levels of endemism and beta diversity, comprises a significant refuge for many birds and other species that have declined or become locally extinct elsewhere, and holds considerable carbon stocks (Watson et al. 2008; Prober et al. 2010; Prober et al. 2012).

Cumulative disturbance within the Great Western Woodlands is estimated to be in the order of 69,000 ha, or 0.43% of its estimated 16 million ha extent. It currently contains 334 operating mines and has 119,303 'abandoned mines' registered within its boundary, as well as 1,310 exploration tenements, 2,826 mining tenements, and 2,938 prospecting tenements together covering 60% of the region (DEC, 2010a; Department of Mines and Petroleum (DMP), 2013b). There is an estimated 150,000 km of linear infrastructure in the region with vehicle tracks making up the majority of the disturbance footprint in the Great Western Woodlands (Raiter, 2016).

The Proposal disturbance represents a very small proportion of the extent of the Great Western Woodlands (0.004%), and would make up less than 1% of the total current disturbance once developed. While these percentages are small, successful rehabilitation of the Proposal and other mining projects is important to ensure the fauna values of the Great Western Woodlands are not significantly affected. Rehabilitation mitigation measures are described in Section 5.6.

At a local scale, the Proposal will not disturb more than 30% of the mapped extent of any floristic communities mapped within the survey area, with the greatest being 30 ha of HS-MWS1 (20% of extent mapped by Botanica (2020c)). Given that more than 80% of every floristic community will remain, the Proposal disturbance is unlikely to have a significant impact on local floristic communities.

The DEs contain several flora and vegetation values that are considered significant. An assessment of the direct disturbance of those values is provided in Sections 5.5.2 – 5.5.8.

Fragmentation

The Proposal will include 650 ha of disturbance and the construction of significant features such as mine pits, haul road and the TSF that can fragment vegetation. This fragmentation is however unlikely to significantly impact local vegetation given that:

- The mining area is less than 3 km across, with all mine pits less than 1.4 km in width;
- The proposed disturbance is relatively small in scale, and the surrounding vegetation is not disturbed or proposed to be disturbed by other proposals; and
- All disturbance will be rehabilitated at the completion of mining (approximately 13 years).

Dust Deposition

<u>Derivation of Conservative Impact Value</u>

There is no current vegetation health impact criteria for dust deposition, and impact values are likely to vary greatly between individual plants. Given the high ecological value of the flora and vegetation of the area, a conservative impact concentration for dust deposition was deemed to be appropriate.

The impact concentration was determined based on a review of dust deposition studies on flora within Australia and across the world, however with a closer focus on studies on Australian flora. Some studies were identified that tested various dust deposition concentrations to determine the deposition concentration where some measurable (non-permanent) health impacts occur.

Other studies recorded the range of actual dust deposition rates occurring at the location of the flora being studied, then determined whether the flora health was affected by that range. The amount of times that a specific dust deposition concentration occurred was not reported in those studies. It is therefore not possible to determine at which point within the recorded dust deposition range that impacts began to occur.

To address this issue, and ensure a conservative impact concentration was used in this assessment, Audalia applied the following logic:

- Exact dust deposition concentrations were noted if the study used a single dust deposition concentration;
- The lowest dust deposition concentration was noted if a study tested multiple dust deposition concentrations and an impact was recorded;
- The highest dust deposition concentration was noted if a study tested multiple dust deposition concentrations and an impact was not recorded; and
- The 20th percentile point of the dust deposition range was noted for each study that recorded ranges (i.e. 80% of the dust deposition range is higher than this value).

The following reports / journal articles were reviewed during the assessment:

- Impacts of dust on plant health, survivorship and plant communities in semi-arid environments (Matsuki *et al*., 2016);
- Mineral particulates and vegetation: Modelled effects of dust on photosynthesis in plant canopies (Doley and Rossato, 2010);
- The effects of dust on vegetation – a review (Farmer, 1991);
- Responses in plants exposed to dust pollution (Sett, 2017);
- Dust collection potential and air pollution tolerance indices in some young plant species in arid regions of Iran (Javanmard *et al*., 2019); and
- Dominant environmental parameters for dust deposition and resuspension in desert climates (Figgis *et al*., 2018).

The results of the assessment are summarised in Table 31. The results have been sorted from lowest dust deposition concentration to highest.

Table 31: Dust deposition study results

Flora	Country / Region	Dust deposition range ($g/m^2/month$)	20th percentile ($g/m^2/month$)	Impact recorded?	Study reference
Triodia spp. (Poaceae)	Australia (Barrow Island, Pilbara)	0.0 – 7.0	1.4	No	Matsuki *et al.*, 2016
Tetratheca paynterae paynterae (Elaeocarpaceae)	Australia (Windarling Ranges, Goldfields)	0.6 – 20.1	4.5	No	Matsuki *et al.*, 2016
Quercus petraea	Europe, Iran	6.1 – 18.3	8.5	Yes	Farmer, 1991
Cotton plants	-	9.0	N/A	Yes	Doley and Rossato, 2010
Gossypium hirsutum	Uncertain origin	12.2	N/A	Yes	Farmer, 1991
Helianthus annus	North America	15.2	N/A	Yes	Farmer, 1991
Phaseolus vulgaris	Americas	18.3	N/A	Yes	Farmer, 1991
Avena sativa, Trifolium repens, Abeta vulgaris, Lolium temulentum	Middle East, Europe and surrounds	21.3 – 45.7	26.2	No	Farmer, 1991
Mangifera indica *Citrus limon*	Southern Asia / India	0.9 – 191.8	39.1	Yes	Farmer, 1991
Sphagnum spp.	Typically Northern Hemisphere	30.4 – 76.1	39.5	Yes	Farmer, 1991
Zea mays	Americas	6.1 – 331.8	71.2	Yes	Farmer, 1991
Brassica campestris	China	91.3	N/A	Yes	Farmer, 1991
Triticum aestivum	Uncertain origin	213.0	N/A	Yes	Farmer, 1991
Tsuga canadenis, Acer rubrum, Quercus prinus, Quercus rubra, Liriodendron tulipifera	Eastern North America	432.2	N/A	Yes	Farmer, 1991

Based on the findings of Table 31, a dust deposition concentration of 8 $g/m^2/month$ was considered to be a conservative impact value for this assessment, given that it is 0.5 $g/m^2/month$ lower than the lowest dust deposition concentration that caused a measurable impact (8.5 $g/m^2/month$ for *Quercus petraea* in Table 31).

<u>Expert Review of Proposed Impact Value</u>

Given the conservation status of *M. aquilonaris,* Audalia engaged David Doley, an Honorary Research Consultant from the University of Queensland, who was the author of 'Mineral particulates and vegetation: Modelled effects of dust on photosynthesis in plant canopies' (Doley and Rossato, 2010) which was referenced in Table 31. His assessment of the proposed impact value is provided below and attached in Appendix 3.13.

For most mineral dusts, their effects on vegetation responses are expressed most clearly in leaf function and its consequences (shoot growth, flowering and seed set). Dust deposition on vegetation affects plant functioning through interception of solar radiation (reducing the rate of photosynthesis in leaves), alteration of the radiant energy balance (reflection, absorption and emission of both short- and long-wave radiation), and by imposing a barrier to gas diffusion on leaf surfaces with stomata (reducing carbon dioxide and water vapour transfer and the processes of photosynthesis and transpiration).

Exact determination of dust deposition on leaf surfaces is difficult because the quantities per leaf are usually small and the composition of vegetation canopies means that there may be substantial variation in the rate of deposition of dust to different portions of the canopy. Because of the difficulty in making precise measurements of dust deposition and its effects in the field, and even in the laboratory, modelling approaches have been adopted to indicate potential effects of different dust exposure and deposition scenarios.

Site Physical Conditions

Rates of dust deposition in the vicinity of the project site vary, but not with any clear seasonal pattern (Figure 49).

The diameter distribution of deposited particles varies with distance from the source, and the effects of a given dust load on leaves are closely and inversely related to particle diameter (i.e. smaller particles have a greater impact than larger particles). In the modelling presented here, a uniform particle diameter of 20.22 μm has been used, based on the predicted mean particle size specified in Ramboll (2020).

Rainfall data for the Proposal indicates that most of the annual rainfall occurs in the winter months. A detailed analysis of the incidence of rain-free periods during the year has not been completed, but long rainless periods are common for any time of the year, but particularly between November and June. Figure 49 presents the monthly mean dust deposition rates (diamonds) and maximum and minimum values at up to eight sites (vertical bars) in the vicinity of the Proposal between November 2018 and August 2019.

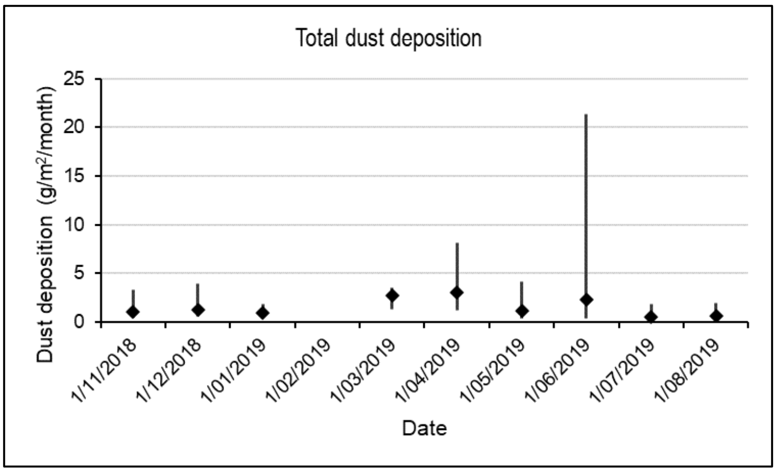


Figure 49: Monthly mean dust deposition rates (diamonds) and maximum and minimum values at up to eight sites (vertical bars) in the vicinity of the Proposal between November 2018 and August 2019.

Species of Concern

The principal species of concern in the Doley (2020) review was *M. aquilonaris*. It is described as an erect straggly shrub to 1.6 m tall, with hairy stems, alternate elliptic to oblong, glabrous (hairless) leaves, which flowers between September and October. The species is perennial, and at least some foliage is assumed to persist for two years. This would provide opportunities for dust deposition at any time of the year.

No information is available on the timing and duration of shoot and leaf growth in this species, but it may be assumed to precede flowering in September. Drought conditions during the summer and autumn would be associated with very little physiological activity in leaves, so dust deposition during this period might have a reduced impact on plant functioning. In the absence of gas exchange between leaves and the air during drought, radiation balance can affect leaf vitality. Dark coloured dusts tend to elevate leaf temperatures by more than light coloured dusts, but the effect may be small compared with the cooling due to transpiration. Therefore, the period of greatest physiological activity in leaves, and susceptibility to dust deposition, is likely to be between August and November (shoot growth to seed set).

Critical processes of pollination, seed set, and germination are considered unlikely to be affected adversely by dust deposition. The flowers appear likely to be insect pollinated Prendergast K. (2019) and seed set is a function of pollination and the availability of accumulated carbohydrate reserves. Germination results in the unfolding of leaves close to the ground, where they are protected by taller vegetation or ground surface irregularities. Deposited dust would only affect germination if it were markedly acidic or alkaline. In addition, new leaves appear at short time intervals, so they are all exposed to limited dust loads while their rates of physiological activity are greatest.

Estimates of Dust Deposition Effects

If threshold rates of dust deposition are set at 4.5 g/m^2/month (a proposed limit during *M. aquilinaris* key growth periods – see Section 5.6.2) and 8 g/m^2/month, it is possible to estimate the effects of dust deposition rates and periods on dry matter production in canopies with the photosynthetic properties described by Doley and Rossato (2010), with a vegetation canopy that displayed 1 m^2 of foliage over 1 m^2 of ground surface (a Leaf Area Index of 1.0) and with the following assumptions:

- The sparse foliage of the shrub is treated as a single leaf layer, fully exposed to dust deposition throughout the period (there is no replacement of foliage at the top of the canopy);
- The canopy is dust-free at the beginning of the calculation period (for example, after it had been washed clean by >10 mm rainfall, or if the plants had been shaken by strong winds);
- Dust deposition is uniform throughout the canopy;
- Constant rates of dust deposition continue for 30 days (1 month), with the calculation of effect made at the end of this period;
- Continuous dust deposition is often assumed to lead to the occurrence of an equilibrium dust load. It is not possible to determine this equilibrium value, so calculations will be made for an accumulation period of 30 days; and
- For leaves of intermediate inclination, this value is set at 0.5 (half of the dust falling into a gauge is intercepted by a leaf (k = 0.5). This value is commonly assumed for randomly oriented foliage. Once the dust is on the canopy, dust light extinction coefficient (kD) is calculated by equation: kD = 0.3043 – 0.0555*ln(Dd), where; Dd = Dust median diameter (μm).

Dust retention coefficient (rD) is the fraction of intercepted dust that is retained on the leaf surface and is modelled as (a) rD = 0.5 (50% retention), which is a reasonably conservative assumption for this species.

It is very well established that the photosynthetic characteristics of different species vary substantially (for example, maximum values of net photosynthesis, A_{net}, may range from 5 - 30 μmol CO_2/m^2 leaf/s), and that the shape of the photosynthetic light response curve also varies between species. However, the relative effects on dry matter production of reduced light interception by different plant canopies are likely to be smaller than the absolute differences in their photosynthetic rates. Therefore, it was considered feasible to apply estimates of relative reductions in dry matter production to species or plant canopies with different physiological characteristics but assigned structural characteristics and durations of exposure.

The scenarios presented here describe net primary production (daily total photosynthesis minus respiration of leaves) (Figure 50). Additional losses of carbon are associated with respiration attributable to plant maintenance and growth, so the effects described here would be less than might be anticipated in the field. Based on the assumption that the conditions described above, Figure 50 presents the estimated reductions in primary dry matter production (P) by leaves of a plant subjected to different rates of monthly dust deposition (D). The curves also describe the time course of effects with increasing duration of deposition, where 30 days represents a total deposition of 4.5 and 8 g/m^2 in a dust gauge.

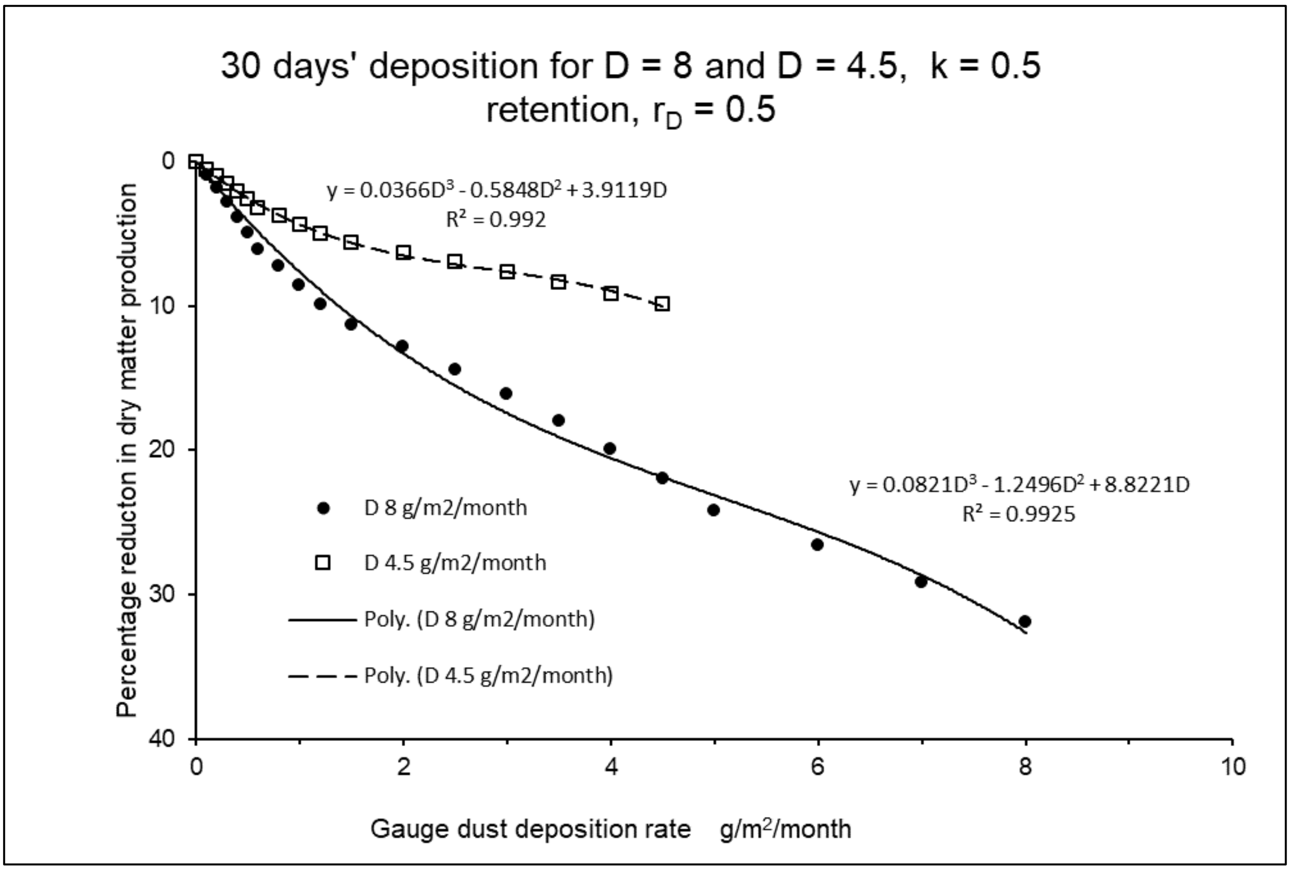


Figure 50: Estimated reductions in primary dry matter production (P) by leaves of a plant subjected to different rates of monthly dust deposition (D)

Interpretation

The effect of dust deposition at 8 g/m²/month on foliage with random orientation depends on the smoothness of the upper leaf surface, and on the consequent retention of dust. If the leaf surface is rough or hairy enough to retain 50% of the intercepted dust (a reasonably conservative assumption), then after one month of deposition, net dry matter production by leaves will have reduced by an estimated 32% (Figure 50). If the upper leaf surface was smooth enough to retain only 30% of the intercepted dust, the reduction in net dry matter production would have been about 15%.

Using the same assumptions, the effect of dust deposition at 4.5 g/m²/month on foliage would result in the net dry matter production by leaves only being reduced by an estimated 10% (Figure 50). If the upper leaf surface was smooth enough to retain only 30% of the intercepted dust, the reduction in net dry matter production would be only about 5%.

An important result is that, if dust is removed by rain washing or by shaking in a strong wind, the response curve is returned to zero deposition.

<u>Dust Impacts on Plants</u>

Dust deposition has the potential to cause the following impacts to plants (Farmer, 1991):

- Reduced growth, photosynthesis and transpiration;
- Increased leaf necrosis (death of leaf cells or tissues); and
- Reduced vegetative and reproductive growth.

The scale of impacts increases with dust deposition rates. It should be noted that the values provided in Table 31 represent a measurable impact value, which for the lower concentrations is likely to be relatively minor impacts. For example the impact value for cotton plants (9.0 g/m^2/month) resulted in only a 3 – 5% reduction in cotton fibre yield (Doley & Rossato, 2010).

Air Dispersion Model

Ramboll Australia Pty Ltd (Ramboll) conducted air dispersion modelling of fugitive dust emissions from mining and processing activities (Ramboll, 2020a; Appendix 3.5) and those associated with the haulage of concentrate from the mine site to the road train transfer area, adjacent to the Coolgardie-Esperance Highway; and the transfer of concentrate from the haul trucks to the road trains (including stockpiling, reclaiming and truck loading) (Ramboll, 2020b; Appendix 3.6).

The CALPUFF modelling system has been used for this assessment. CALPUFF provides a non-steady state modelling approach which evaluates the effects of spatial changes in the meteorological and surface characteristics and has been listed by the United States Environmental Protection Agency as an alternative model for situations involving complex terrain and wind conditions.

Meteorological Data

In the absence of site-specific meteorological monitoring data suitable for use in dispersion modelling, The Air Pollution Model (TAPM) (Version 4) was used to generate a gridded meteorological dataset for the model domain. The meteorological component of TAPM predicts the local-scale meteorological features, such as sea breezes and terrain-induced circulations, using the larger-scale synoptic meteorology as boundary conditions combined with other data including terrain, land use, soil and surface types.

Factors Influencing Dust Emissions

To predict particulate deposition rates in a realistic manner, hourly estimates of particulate emissions are required from all major sources in the area. Factors which are important for particulate generation include:

- Ore type being handled - this is related to the size distribution of the material, shape and composition of the fines fraction;
- Moisture content - increasing the moisture content decreases the dustiness of the ores and there is normally a moisture threshold above which particulate generation by material handling is negligible, known as practical extinction. This occurs as moisture acts to apply adhesive forces between particles;
- The operation occurring - factors which are important are the drop height, the degree to which the falling ore is exposed to the wind such that winnowing can occur, and the particulate control mechanism used. Control mechanisms may include enclosing the operation, the use of water sprays and particulate extraction to a bag filter or to a wet scrubber;
- Quantity of ore / overburden being moved and the number of movements;
- Size of stockpiles and level of activity;
- Level of vehicle traffic; and
- Ambient wind speed - for material handling operations exposed to the air, particulate emissions increase with increasing wind speed. For wind erosion, particulate emissions

are negligible below a wind speed threshold, but increase rapidly above the threshold. Dust emissions from wind erosion are also dependent on the erodibility of the material which is dependent on the size distribution of the material and whether a crust has been developed.

Modelling Input Data and Assumptions

Dust deposition modelling for the mine and haul road were conducted by Ramboll (2020a, 2020b respectively). The model predicted potential dust deposition rates associated with fugitive particulate emissions from the Proposal.

Emission factors and control efficiencies were based on the National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining 2012 Version 3.1 (NPI, 2012). The emission factors are considered conservative in that they allow for variation in the moisture content of the ores and some failure in control equipment.

Some of the emissions factors rely on moisture content in determining an emission rate. The moisture content of the ore and overburden is likely to be low and therefore the default NPI values for 'low' moisture ores (i.e. those with a moisture content less than 4%) were subsequently adopted in the model. A default silt content of 10% as outlined in the NPI emissions manual was also utilised.

The calculation of emission estimates associated with 'worst-case' mining activities was based on the anticipated mining rate for Year 1. Year 1 is considered the 'worst-case' scenario for potential dust deposition impacts, as it represents the highest mining production rate, within closest proximity to the *M. aquilonaris* sub-populations. The calculation of emission estimates associated with 'mid-schedule' mining activities is conservatively based on the mining schedule for Year 11, as this represents the highest production rate for below-ground level activity within the Vesuvius pit. The emission estimates for excavating, truck loading, stockpiling, reclaiming, processing and waste rock dumping were subsequently based on the annual throughputs for the respective periods.

Emission estimates were calculated assuming operations occur during the day shift only (nominally between 06:00 and 18:00 hrs), as advised by Audalia. The effects of wind and rainfall on emission estimates were also taken into consideration.

The determination of emissions associated with dozing operations within the Vesuvius pit assumes operational controls are implemented to restrict dozing activity when the wind direction falls within the 'arcs of influence' for sub-populations 1b and 1c. The extents of these arcs are illustrated in Figure 51 (namely between 60° and 285° for sub-population 1b and between 325° and 195° for sub-population 1c).

Analysis of the TAPM predicted meteorological data generated for the Proposal, indicates that during operating hours (nominally between 06:00 and 18:00 hrs), winds most frequently fall within the specified arcs of influence during the summer months, and less frequently during the winter months.

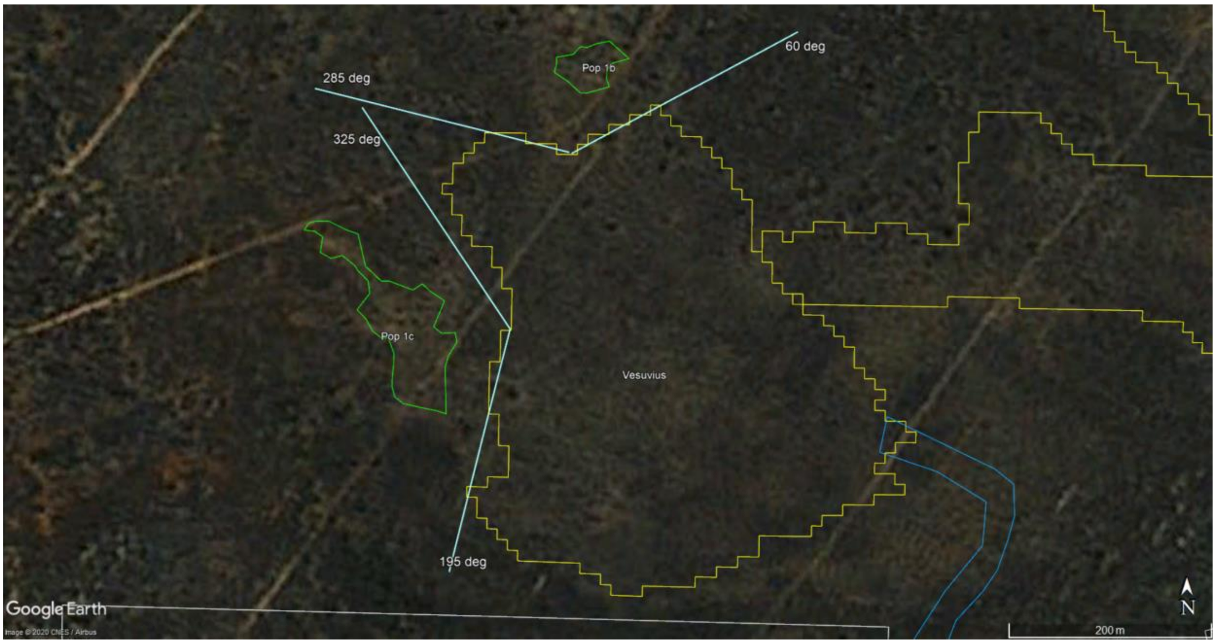


Figure 51: Arcs of influence for *M. aquilonaris* sub-population 1b and 1c

Modelling Results

Figure 52 and Figure 53 show the maximum predicted monthly average dust deposition rate at the mine during Year 1 and Years 2 – 11 respectively. The haul road was predicted to result in a maximum dust deposition rate of 4.8 g/m^2/month at the receptors used in the model (shown in pink in Figure 52 and Figure 53).

Assessment

An estimated 141 ha of vegetation within the Mine DE is predicted to experience maximum dust deposition rates of more than 8 g/m^2/month and therefore may experience some health impacts during some periods during mining (most likely in Year 1). The potentially impacted area is at its maximum in Year 1 (Figure 52) and will reduce significantly after Year 1 (Figure 53). An additional 35 ha of vegetation within the Haul Road DE is predicted to experience maximum dust deposition rates of more than 8 g/m^2/month (Figure 56) and therefore may experience some health impacts during the operational period of the Proposal.

The health of five floristic communities are predicted to be potentially impacted (listed as indirect impacts in Table 34 and shown in Figure 55), with HS-MWS1 the only unit predicted to have more than 10% of its mapped extent potentially impacted. This floristic community is considered to be locally significant and therefore has been assessed in detail in Section 5.5.8.

Dust deposition may also impact the environmental values described in Section 5.3.8, therefore dust deposition impacts have been assessed for each value in Section 5.5.2 – 5.5.8.

The dust deposition modelling does not explicitly account for rainfall (washing dust from leaves) and provides a conservative estimate of potential impact areas.

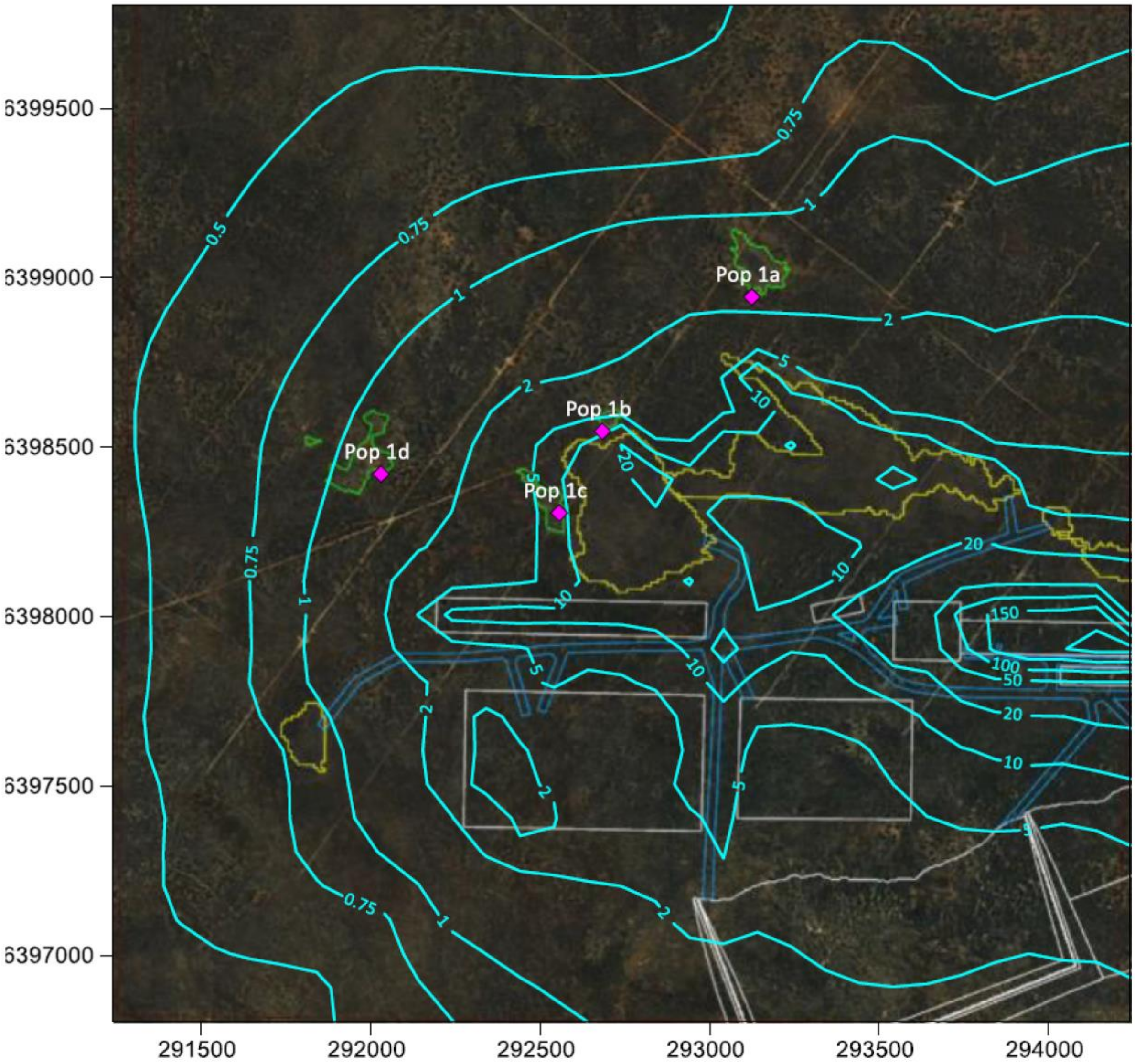


Figure 52: Maximum predicted monthly average dust deposition rates – Year 1

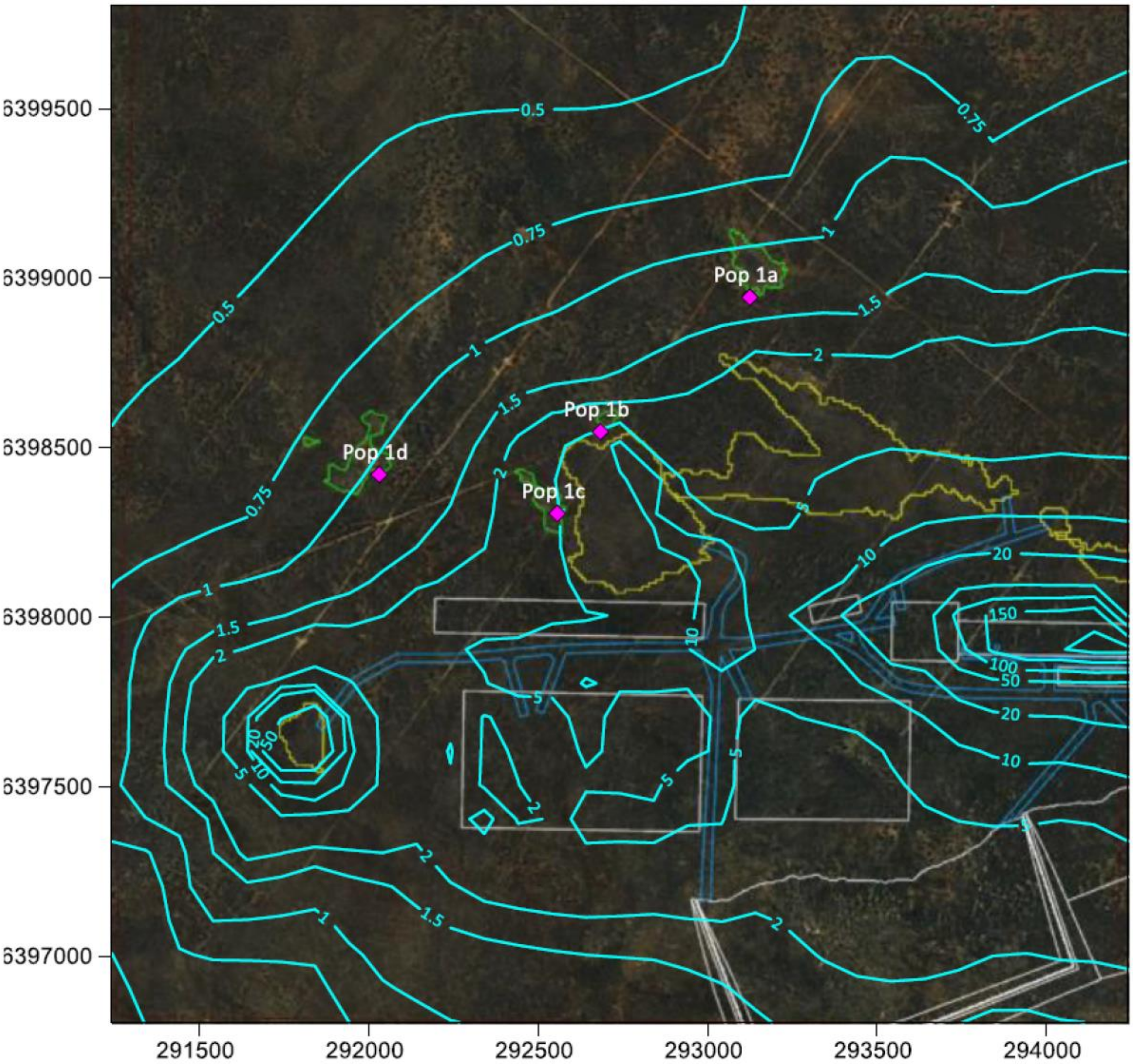


Figure 53: Maximum predicted monthly average dust deposition rates – Years 2 – 11

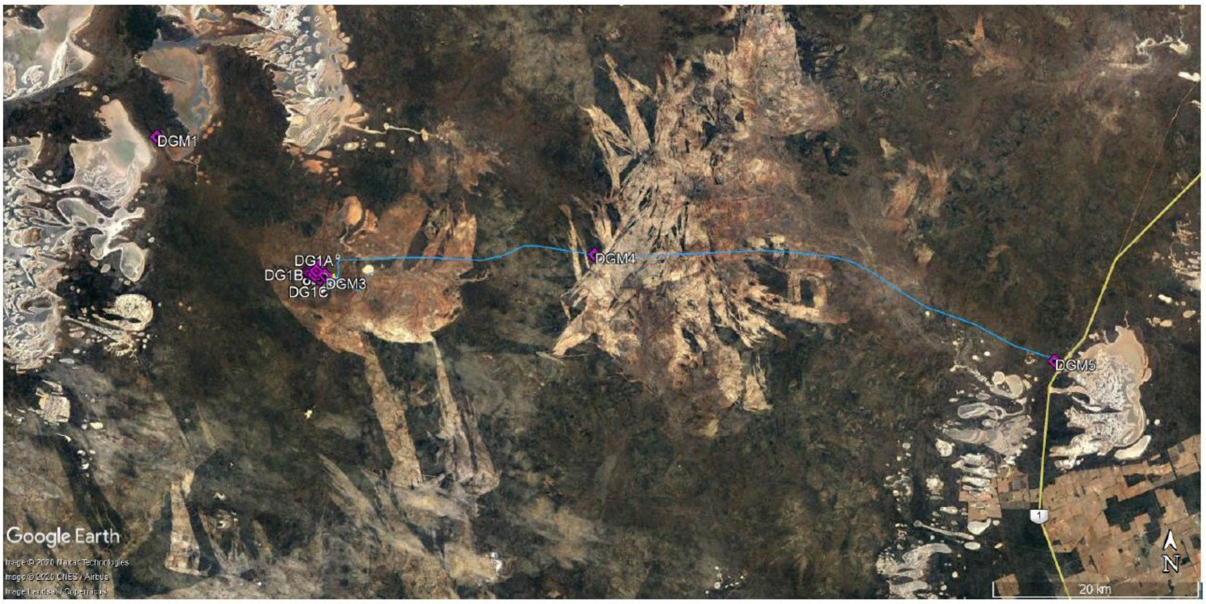


Figure 54: Location of Dust Deposition Monitors – Haul Road

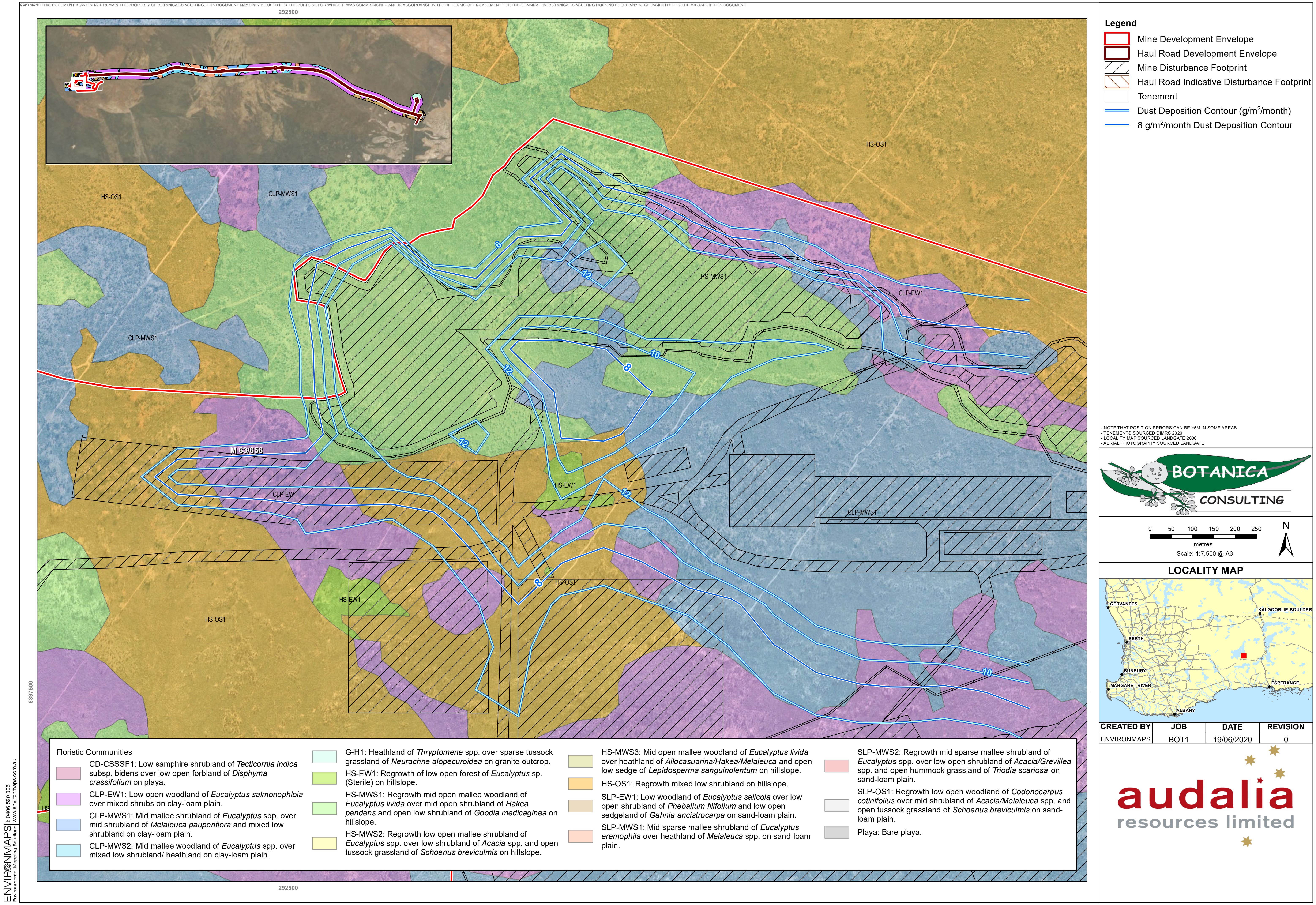


Figure 55: Dust deposition within floristic communities (mining area)

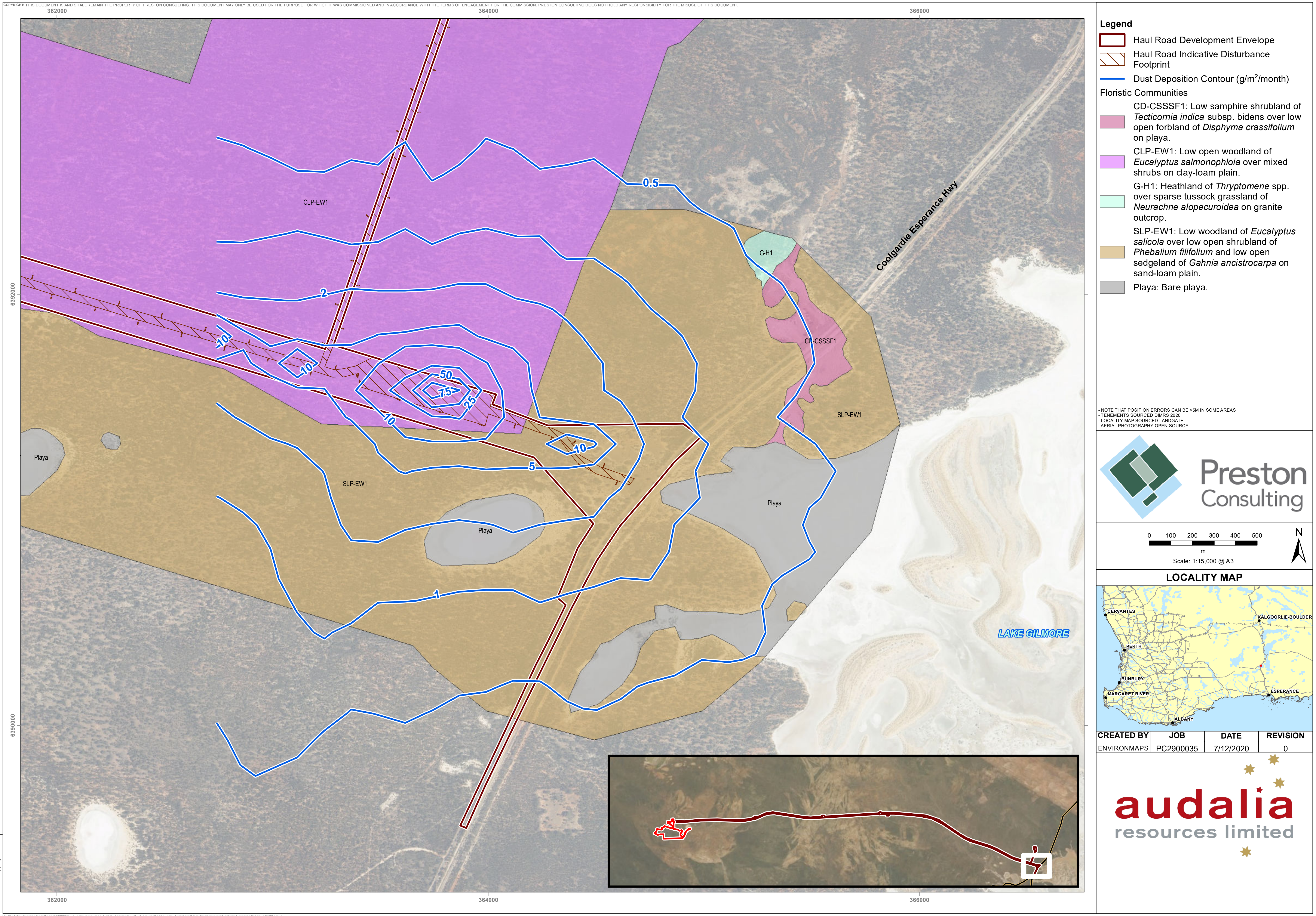


Figure 56: Dust deposition within floristic communities (Transfer Station)

Changes to Hydrological Regimes

Section 9 (Inland Waters) provides an assessment of the potential impacts of the Proposal on surface water regimes within the Mine and Haul Road DEs. The findings of those assessments is summarised below as applicable to impacts to flora and vegetation.

Several drainage lines will be intersected by mining operations (Figure 109), with diversions proposed at the TSF, evaporation ponds and Pinatubo pit (Figure 3). These diversions are high in the catchment (receiving minimal runoff) and will be engineered structures designed to allow the majority of the flows to be maintained. As such the impact to downstream vegetation is likely to be minor.

The location and route of the haul road, incorporation of natural drainage considerations into road design, the scale and frequency of drainage features and runoff events means that the extent of disruption to surface flows is not expected to be significant. The proposed monitoring, maintenance and retro-fitting of improved drainage where required, will further reduce the frequency and consequence of any impacts to surface drainage (Section 9.6).

Based on the above it is unlikely that the Proposal would impact hydrological regimes to an extent that downstream or upstream vegetation would be significantly affected.

Treated Sewage Disposal

An estimated 15 - 45 kL of sewage from the accommodation camp will be treated at a wastewater treatment plant each day. The treated wastewater will be disposed of via irrigation to a dedicated vegetated area adjacent to the camp. The wastewater will be treated to a minimum low exposure risk level quality and licenced under Part V of the EP Act and the *Health Act 1911*.

The Part V EP Act Licence will require the irrigation area to be sized such that nutrient loading does not significantly affect the vegetation within and surrounding the irrigation area.

Hydrocarbon or Saline Water Spills

Considering the hydrocarbon use described in Section 8.5.6, and the small scale of operations planned for the Proposal, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon contaminated soil that can be remediated via passive means such as bioremediation. Proposed control measures are identified in Section 5.6 and are designed to further reduce the risk of vegetation impacts from hydrocarbon spillage.

Saline water pipelines will run from the borefield to the RO Plant, then from the RO Plant to the evaporation ponds. A rupture of these pipelines has the potential to release saline water into the surrounding vegetation if it were to occur. Leak detection is proposed for these pipelines, which will trigger an automatic shut-down of the borefield or RO Plant feed. This will restrict the volume of saline water that would be released into the surrounding environment. Audalia will also investigate the option of containing a spill if it was to occur, by placing the pipes in a system of bunds and sumps designed to contain spillage. This option however may not be pursued along the whole length of the pipelines as the area of vegetation likely to be affected by a spill may be less than the clearing required to develop this containment infrastructure. The details of these systems are generally planned and managed via a Works Approvals under Part V of the EP Act (for the RO Plant, evaporation ponds and Process Plant) and a Mining Proposal under the Mining Act. Additional mitigation measures are proposed in Section 5.6 to minimise the change and potential impact of a saline water pipeline spill.

Weeds

Weeds have the potential to outcompete and displace native vegetation if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site. Additionally, favourable conditions for weed growth may be encouraged by watering and nutrient loading from the irrigation of treated wastewater.

Nine introduced species were identified during flora/ vegetation surveys (Botanica, 2020c). According to the DPIRD database, none of these taxa are listed as Declared Plants under Section 22 of the BAM Act. Weeds were mostly identified within floristic community CLP-EW1 which is the most widespread community identified within the DEs (1,237 ha). Vegetation within the DEs ranges from 'good' to 'very good' with majority of the DEs in good condition. No weed infestations were identified within the DEs with only isolated records of weeds observed during flora/ vegetation surveys which were not outcompeting native vegetation (Botanica, 2020d; Appendix 3.10).

Given the presence of nine weed species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with native species (Section 5.6).

Increased Fire Risk

Bushfires are often caused by lightning and are considered a natural part of the environment as they can assist with regeneration of some species and ecosystems, however increased fire intensity and frequency can impact local flora and vegetation.

Vegetation in the Proposal DEs has been subjected to multiple recent fires. The Mine DE and surrounds was subjected to a major fire in 2010 with some areas subjected to multiple successional fires in 2010 (not available on Landgate database). In February 2015, the area was again subjected to fire (observed by Audalia staff in the area) however this fire has not been recorded on the Landgate database. In 2019, fires occurred directly west of the Mine DE within the Honman Ridge area. Given this level of fire activity, much of the vegetation within the Mine DE and surrounding region in various stages of regrowth.

Mining activities have the potential to ignite bushfires through hot work and other activities, however with appropriate firefighting and prevention management measures in place (Section 5.6), the development of the Proposal will provide improved access to the region and improved ability to fight fire outbreaks and prevent them from spreading. The potential for increased fire risk is therefore expected to not be significant.

Summary

The assessment above identified that the Proposal was unlikely to result in significant impacts to general flora and vegetation, however there are potential impacts to specific flora and vegetation values that require further assessment. These assessments are provided in Sections 5.5.2 – 5.5.8.

5.5.2 *MARIANTHUS AQUILONARIS*

Background

The Proposal that was originally referred to the EPA under Section 38 of the EP Act included the disturbance of *M. aquilonaris*; a Threatened Flora taxon pursuant to the BC Act. Based on the mine plan that was referred, a predicted 24% of known *M. aquilonaris* individuals would have been disturbed.

Audalia has commissioned numerous regional searches for this species and no other populations have been found during these surveys, which has confirmed that the sub-populations at Medcalf are significant for the survival of this species.

Given the restricted range and small population of *M. aquilonaris,* Audalia has substantially altered their mine plan to avoid mining within or adjacent to the *M. aquilonaris* sub-populations, and minimising indirect impacts. This has significant economic implications, as the highest grade ore resource is located within and adjacent to the sub-populations.

This section assesses the potential impacts of the Proposal on the following:

- *M. aquilonaris* individuals;
- *M. aquilonaris* sub-populations;
- Optimal habitat for *M. aquilonaris*;
- Sub-optimal habitat for *M. aquilonaris*; and
- Critical habitat for *M. aquilonaris*.

Population 1f

Population 1f is a previous record of one individual, last recorded by DBCA in September 2016, which has never been located by Botanica over several attempts (in 2015, 2017 and 2019) despite Botanica being provided with GPS coordinates, DBCA database search records and a photo of the original record (i.e. Botanica was able to verify that they searched the same location as the photo). This is likely to mean that the individual did not survive. Population 1f is therefore not a current individual / sub-population.

Population 1f was recorded in sub-optimal habitat; outside of the shallow gravel over indurated mottled zone soil type, which is the only known soil type to support this species and has been described as optimal habitat for *M. aquilonaris* (Section 5.3.4). It is likely that the individual was able to survive for a period within sub-optimal habitat before perishing, and similar events may occur within other areas of sub-optimal habitat when conditions are suitable.

Based on the above, while Population 1f remains a sub-population record, it has been assessed separately to the other sub-populations for the following reasons:

- No individuals are currently present; and

- While a seed bank is likely to be present in the immediate vicinity of the record, it does not occur within optimal habitat, which means that any new individuals would find it difficult to become established.

Direct Disturbance

As discussed above, Audalia has substantially altered their mine plan to avoid direct disturbance impacts to current *M. aquilonaris* individuals and sub-populations, and as a result the DEs were revised to exclude the following (i.e. will not be disturbed by the Proposal):

- All current *M. aquilonaris* individuals;
- All current *M. aquilonaris* sub-populations;
- *M. aquilonaris* optimal habitat; and
- All catchment areas upslope of current *M. aquilonaris* areas of occupancy (sub-populations).

Measures were also taken to minimise disturbance within *M. aquilonaris* sub-optimal and critical habitat during Proposal design:

- The abandonment bund was located as close as possible to the zone of instability; and
- The abandonment bund will be constructed in a linear manner (i.e. disturbance will be within a narrow strip), which avoids any disturbance of habitat between the bund and the mine pit crest.

The Proposal will require 1.51 ha of disturbance within sub-optimal habitat for *M. aquilonaris*, which also forms part of the critical habitat for this species (i.e. all disturbance within critical habitat is limited to sub-optimal habitat). The disturbance will be required for the Vesuvius mine pit and associated surrounding abandonment bund, in the vicinity of sub-populations 1b and 1c (Figure 57). This disturbance equates to 2.87% of the total extent of sub-optimal habitat and 2.34% of the total extent of critical habitat.

The Proposal will also result in the loss of sub-population 1f, which as of the most recent survey (Botanica in 2019) does not contain any individuals and is not optimal habitat for this species. Nevertheless, there may be a seed bank within the vicinity of this record. The topsoil in the area and the vicinity of sub-population 1f will be collected and stored properly before any disturbance occurred (refer to Section 5.6).

While this disturbance is only a small percentage of the sub-optimal habitat and critical habitat for *M. aquilonaris*, the significance of this disturbance is best assessed in context with indirect impacts. This assessment is provided in the summary at the end of Section 5.5.2.

Loss of Habitat due to Potential Mine Pit Wall Erosion

There is currently 0.95 ha of sub-optimal and critical habitat that lies between the mine pit and abandonment bund and will not be cleared (Figure 57). This area of sub-optimal and critical habitat lies within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure.

Figure 58 and Figure 59 provide cross-sections showing the proposed pit crest and abandonment bund in relation to the *M. aquilonaris* sub-populations and optimal habitat.

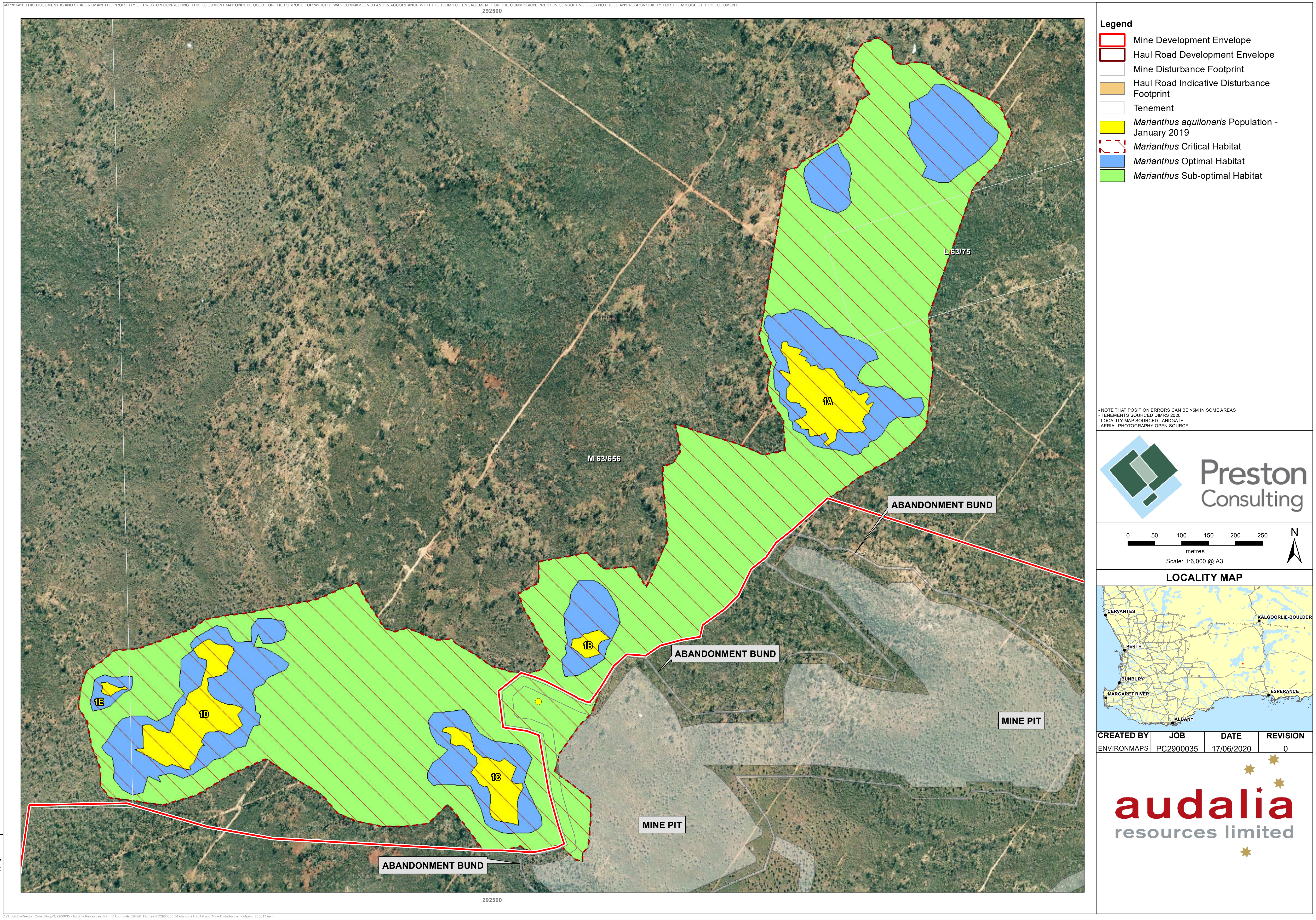
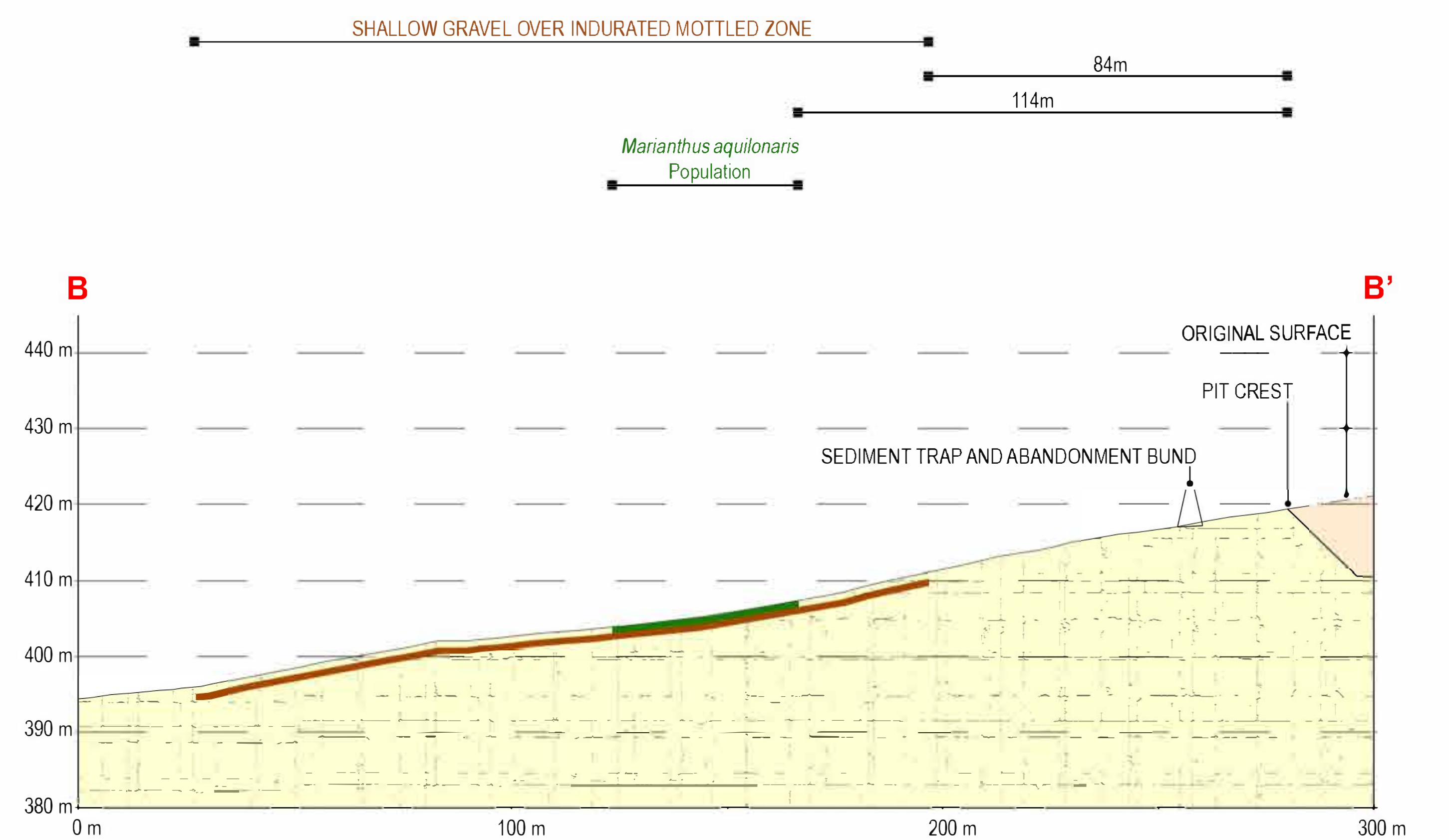
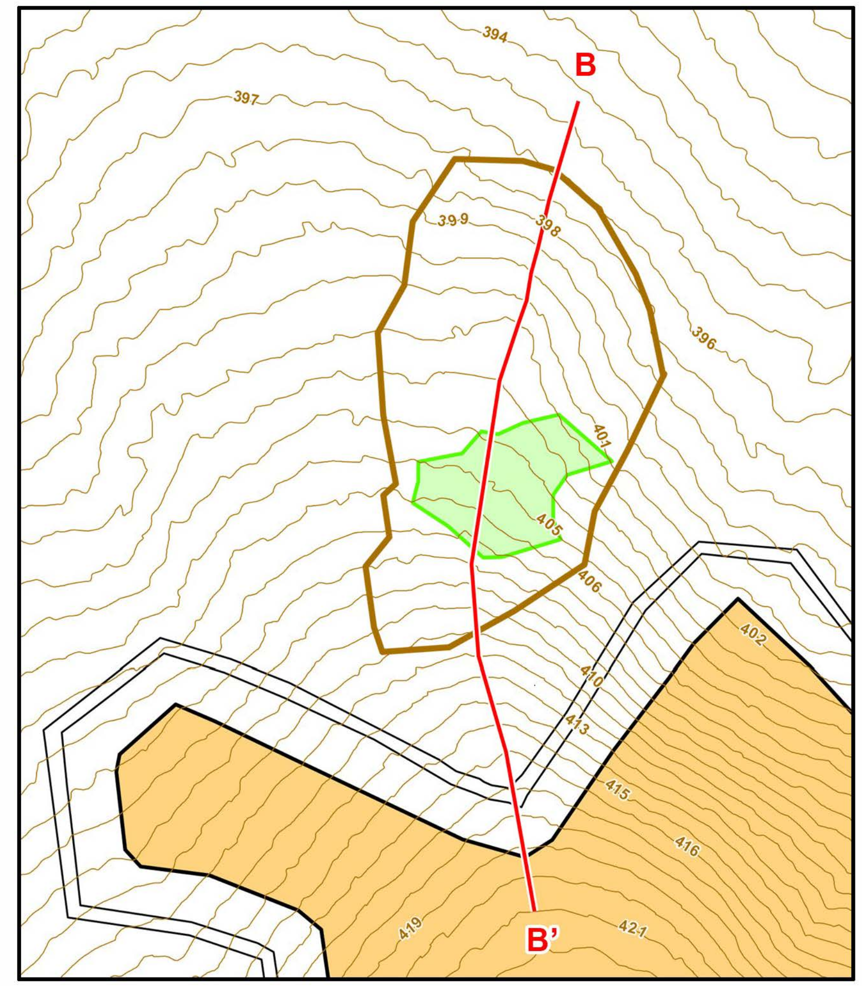


Figure 57: Area of sub-optimal and critical habitat to be disturbed

CROSS SECTION THROUGH PIT IN RELATION TO *MARIANTHUS AQUILIONARIS* POPULATION





Legend

- Cross Section Transect
- Contour (mAHD)
- Sediment Trap and Abandonment Bund
- Pit Crest
- Shallow Gravel Over Indurated Mottled Zone
- *Marianthus aquilonaris* Population January 2019

0 50 100 150

N

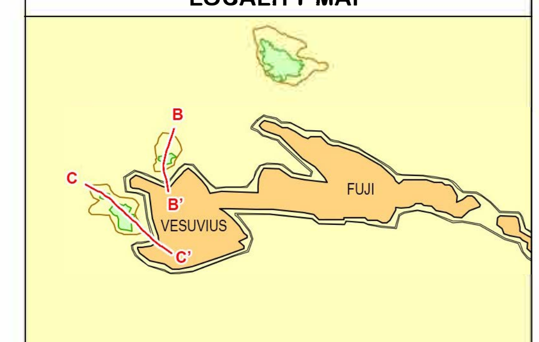
0 25 50 m
Horizontal Scale

0 12.5 25 m
Vertical Scale (VE=1.742)

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- NOT TO BE USED FOR ENGINEERING PURPOSES

Preston Consulting

LOCALITY MAP



CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900035	08/07/2020	0

audalia resources limited

ENVIRONMAPS Environmental Mapping Solutions | t: 0406 590 006 | www.environmaps.com.au

Figure 58: Cross-section of mine pit and *M. aquilonaris* sub-population 1b

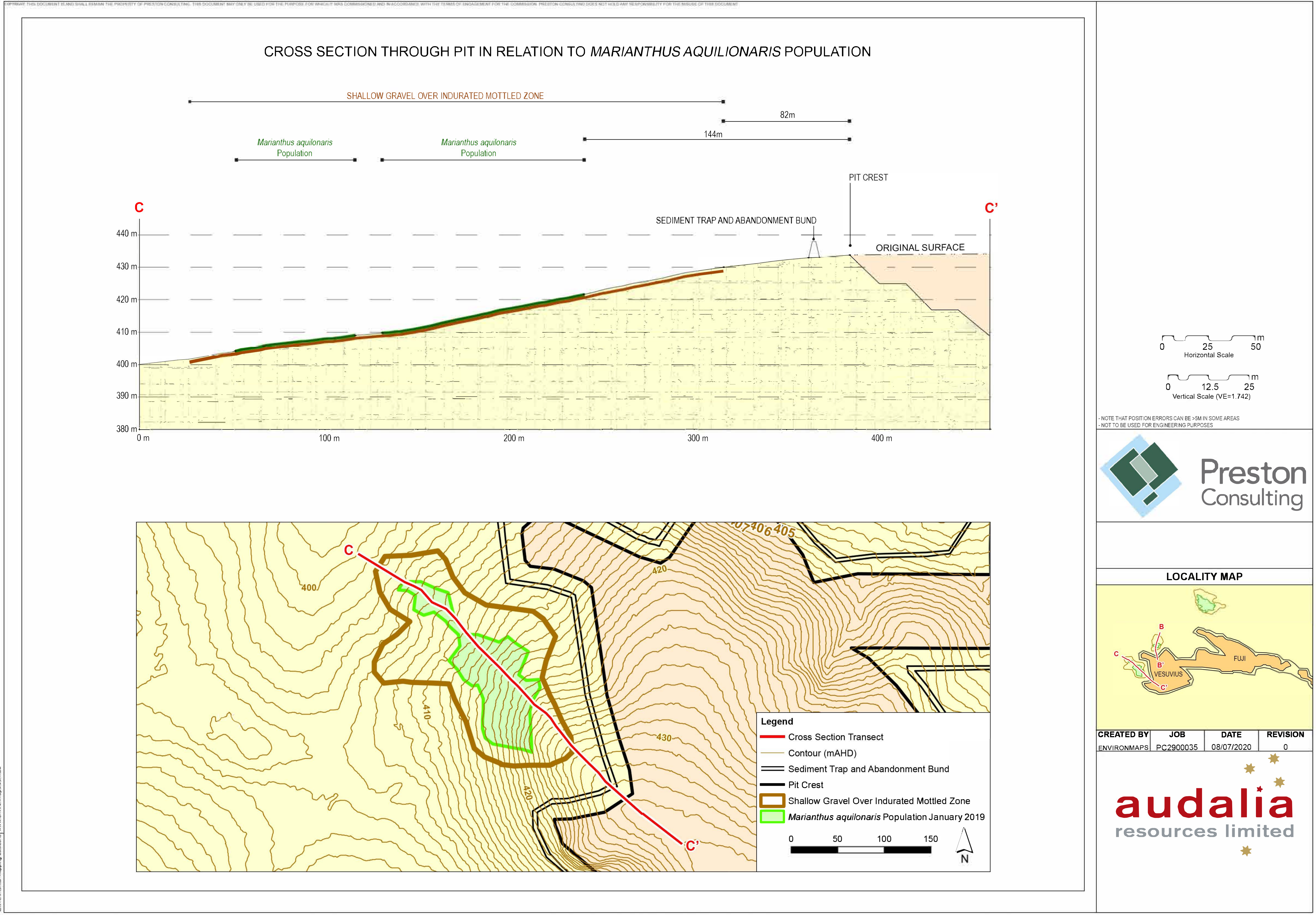


Figure 59: Cross section of mine pit and M. aquilonaris sub-population 1c

Dust Deposition

The Ramboll (2020a) modelling report predicted that the following *M. aquilonaris* individuals or habitat areas would experience dust deposition above 8 g/m^2/month, the conservative impact value described in Section 5.5.1 outside of the key growth period of August to November (noting a lower 4.5 g/m^2 limit will be imposed during this period, refer to Section 5.6.2):

- Six individuals within sub-population 1b;
- 0.01 ha of the area of occupancy of sub-population 1b;
- 0.47 ha of optimal habitat of sub-population 1b and 1c;
- 2.24 ha of sub-optimal habitat; and
- 2.71 ha of critical habitat.

These areas are shown on Figure 60.

The six individuals represent 0.04% of the current recorded *M. aquilonaris* population, and 2.4% of the total individuals within sub-population 1b, with the 0.01 ha they inhabit representing 0.22% of the area of occupancy of the *M. aquilonaris* sub-populations. These six individuals occur at the southern edge of sub-population 1b, adjacent to an existing access road (Figure 52). Dust emissions from the Proposal may result in a decline in health of these six individuals for the first year of mining, while overburden is being removed, then dust levels are predicted to decrease below 8 g/m^2/month for the remainder of the mine life (Figure 53).

The predicted impact to *M. aquilonaris* habitat represents 2.79% of the mapped extent of optimal habitat, 4.26% of sub-optimal habitat, and 4.20% of critical habitat. Dust emissions from the Proposal may result in a decline in health of vegetation within these habitat areas for the first year of mining, while overburden is being removed, then dust levels are predicted to decrease below 8 g/m^2/month for the remainder of the mine life (Figure 53).

Audalia has committed to a number of dust mitigation measures (Section 5.6) and will implement the Dust Control Management Strategy provided in Appendix 10 in order to ensure that dust emissions are minimised as much as practicable during the life of the Proposal and at closure.

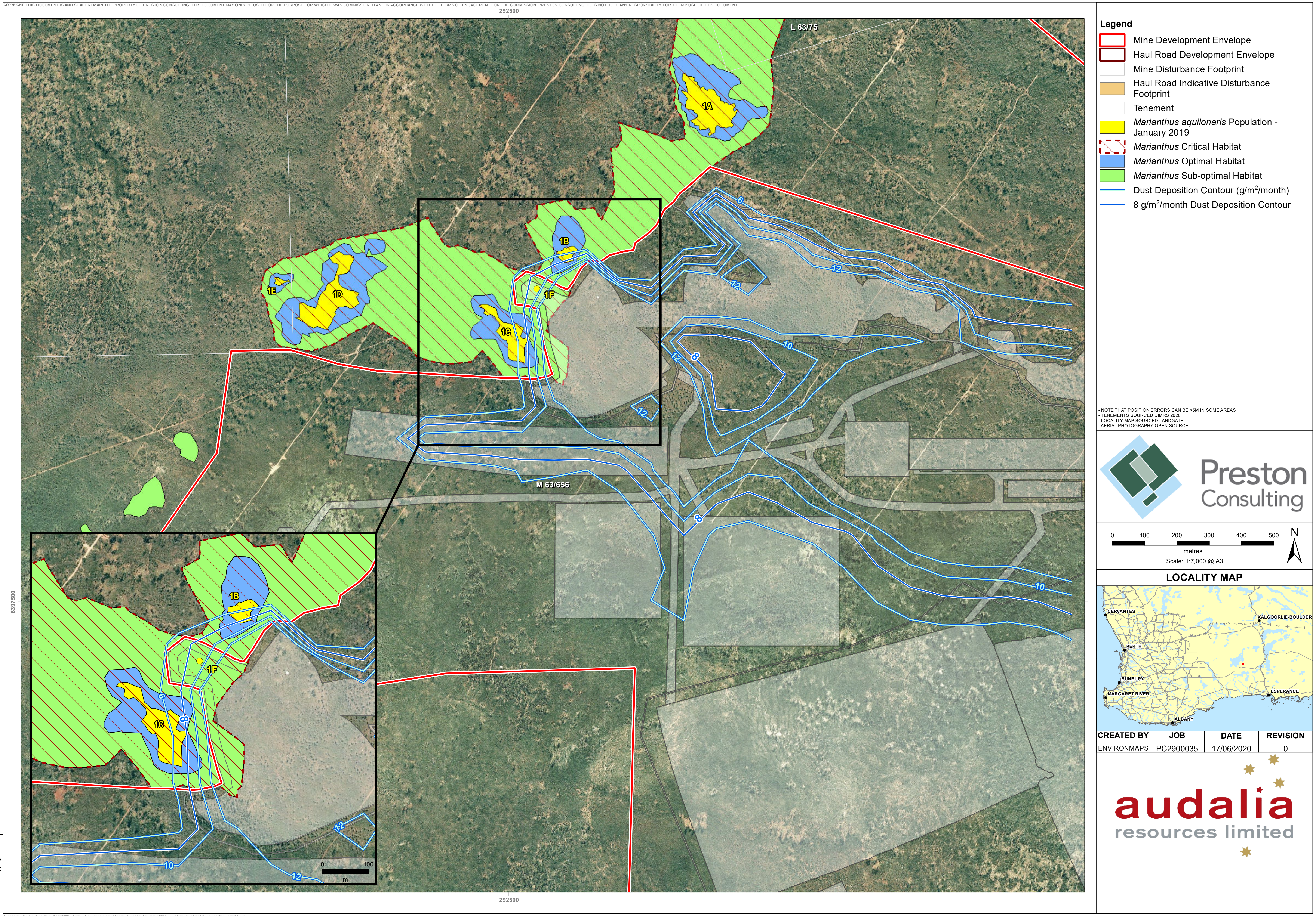


Figure 60: Predicted maximum dust deposition rates in proximity to M. aquilonaris sub-populations (Year 1)

Fragmentation of Sub-Populations

The Proposal includes mining between sub-population 1b and 1c, resulting in an estimated 50 m wide cleared area. This cleared area has the potential to fragment these two sub-populations, resulting in a reduction in genetic exchange.

DBCA conducted an assessment of the genetic diversity of the *M. aquilonaris* sub-populations (DBCA, 2019; Appendix 3.2). The assessment identified that:

- The level of differentiation among the sub-populations is high given the small geographical distance between them, suggesting that there is limited genetic connectivity;
- The majority of seedlings (96%) from sub-population 1b tested for paternity were fathered by plants within the same sub-population; and
- Only a small number of seedlings are receiving a pollen contribution from other sub-populations.

The assessment demonstrated that genetic flow between sub-population 1b and 1c is low, but limited genetic flow does occur. The presence of a 50 m wide mine pit between these sub-populations is unlikely to significantly reduce this genetic flow to a level that would significantly impact the viability of the *M. aquilonaris* sub-populations, given that pollinators are airborne and are likely to be able to fly over or around the mine pit.

The Proposal does not interfere with the potential genetic exchange between other sub-populations.

Changes to Microclimate

The Proposal includes the excavation of mine pits in proximity to *M. aquilonaris* sub-populations and these excavations have the potential to change the microclimate of the immediate area around the mine pit.

<u>Background and Completed Studies</u>

Microclimate is a set of local atmospheric conditions that differ from those in surrounding areas. The extent of the difference is usually slight, but may occasionally be substantial. Climate is defined statistically using spatial and temporal variation of mean values of parameters. The key parameters of temperature, solar radiation, wind speed and direction, humidity and even rainfall need to be persistently different over timeframes that make them statistically significant.

One key contributing factor of microclimate is the slope and aspect of an area. North-facing slopes in the Southern Hemisphere are exposed to more direct sunlight than south-facing slopes and are therefore warmer for longer periods of time. This results in a warmer microclimate on north-facing slopes, which is generally where all of the *M. aquilonaris* sub-populations occur.

Historically little work has been done on the potential for an adjacent excavation to influence microclimate. A literature review did not reveal any substantive publications that modelled the microclimate implications of an excavation within proximity to a population of plants in the natural environment.

Computational Fluid Dynamics (CFD) has been used to model the possible changes to key microclimate elements associated with the presence of the mine voids in proximity to the *M.*

aquilonaris sub-populations. This is a technique used to determine the impacts of buildings on airflow in the built environment. In this case the CFD model used the mine plan excavation data and superimposed the landform changes associated with the mine. With no waste rock storage above ground, the key landform feature of the Proposal is the mine voids, which are also the closest mining feature to the *M. aquilonaris* sub-populations.

The meteorological data prepared by Ramboll for the dust deposition study (generated by prognostic meteorological component of the CSIRO developed model TAPM) was used as the input for the CFD model. The flow domain is discretised using approximately 125 million computational cells concentrated in the lower portion of the domain close to the ground and in the central part of the domain where the mining pits and *M. aquilonaris* sub-population areas are located. The average size of the individual computational cell in this region is 4 m x 4 m horizontally and 2 m in height, although the height of the cells close to the ground become progressively smaller. In the CFD-analysis an atmospheric boundary layer (ABL) wind profile is prescribed at the outer boundary of the flow domain upstream of the mining area, while a zero-gradient flow condition is used for the downstream boundaries. The terrain (inside the flow domain) determines the flow characteristics around the mine voids and *M. aquilonaris* population areas.

The modelling shows changes from current conditions in the form of 'heat maps' i.e. the relative changes to microclimate associated with the nearby presence of a mine void.

The CFD modelling report (Ramboll, 2020c) is included as Appendix 3.7.

<u>Assessment</u>

Solar radiation and rainfall are two key drivers of microclimate. The partitioning of solar radiation inputs to the land and vegetation is an influence on the resultant microclimate and is the outcome of a complex range of variables. Similarly, soil evaporation and evapotranspiration is driven and limited by a range of interacting factors that are complex to measure, model and predict. These include solar radiation, rainfall, temperature, humidity, air flow (often measured as windspeed and turbulence).

The mining operations will not change the aspect of the land supporting the sub-populations, hence there will be no changes to the solar radiation regime within the sub-populations.

It has been noted that all of the *M. aquilonaris* sub-populations are located in the range 380 m - 425 m RL. This may reflect a preference or requirement for particular conditions associated with altitude (such as additional access to moisture via increased fog / cloud activity). The Proposal will not change the altitude of the sub-populations, so no changes to this aspect of microclimate are expected.

The Proposal is predicted to alter the wind conditions in close proximity to the mine pits, which may in turn alter the evaporative demand on the affected vegetation. Evaporation rates are dependent upon a number of factors, including solar radiation, relative humidity, temperature and windspeed as well as the characteristics and moisture status of the vegetation itself. The CFD model is unable to model relative humidity and temperature directly, but is able to determine changes to two key rate-limiting aspects of evaporation:

- Air flow velocity gradients close to the ground (ground shear); and
- Mixing rates in the boundary layer above (gust factor).

These two factors have therefore been selected as being representative of the potential impacts that the presence of the mine pits could have on the microclimatic conditions experienced within the *M. aquilonaris* sub-populations. Ground shear is considered to be of most importance to this assessment as it is more representative of the lower layer of atmosphere where changes in wind speed would likely affect evaporative demand, whilst the gust factor is a measure of the gust variations.

As the *M. aquilonaris* sub-populations are located west and north of the proposed mine pits, it has been assumed that any changes in growth conditions are most relevant when the wind is blowing from the east and south (i.e. the air will flow over the mine pits prior to flowing over the sub-populations). However, to ensure that no relevant wind directions are excluded from the assessment, wind directions from the east (90°) to the west (270°) were also included, with a resolution of ten degrees between each run of the model.

To provide an overview of the potential changes in wind conditions, annual 'heat maps' of relative increase (change) have been prepared, where the wind statistics have been embedded. Only winds above 2 m/s have been included in the underlying statistics when generating the maps. Below 2 m/s, wind fields are more strongly affected by thermal differences and flow tends to be laminar rather than turbulent. As winds below 2 m/s are experienced on average more than 16% of the time throughout the year, the maps provided are believed to be conservative with respect to changes in microclimate. Where the differential in these factors between pre- and post-mine is negligible, no change in microclimate associated with changes to air flow would be expected.

Figure 61 provides the 'heat maps' for *M. aquilonaris* sub-population 1b and 1c. Since completion of the CFD wind assessment, the footprint of the Vesuvius pit has been revised and the distance between the proposed pit crest and sub-populations 1b and 1c has increased. The revised pit boundary is set back an additional 30 - 50 m from the sub-population 1b buffer zone; and between 15 - 50 m further back from the sub-population 1c buffer zone (Figure 62). In effect, the minimum distance between the pit crest and sub-population 1b has increased from 30 m to 60 m, and the minimum distance between the pit crest and sub-population 1c has increased from 30 m to 45 m.

Assuming a similarly shaped mine pit, the effect of this revision is not likely to have a significant impact on computed wind characteristics, apart from a corresponding shift of the location of wind shear and gust factors, generated by the terrain features. The predicted annual increase in ground shear and gust factor at sub-population 1b and 1c are therefore likely to be significantly lower than those shown in Figure 61, given that modelling results indicate a rapid decrease in relative change in these gradients with increasing distance from the modelled pit crest. Assuming that wind gradients produced by the pit crest of the revised Vesuvius pit footprint is similar to those predicted for the original pit footprint (based on similarly shaped pits as noted), an indication of the likely effect of increasing the distance between the pit crest and *M. aquilonaris* sub-populations can be inferred from the dotted contours illustrated on Figure 61.

Figure 58 and Figure 59 provide cross-sections showing the proximity of the proposed pit crest in relation to the *M. aquilonaris* sub-populations and optimal habitat.

The microclimate of the remaining sub-populations was predicted to be unaffected as they were outside the sphere of influence of wind flow changes.

As indicated in Figure 61, the predicted maximum increase in ground shear for sub-population 1b located north of the Vesuvius pit would likely be less than 5% on an annual basis. For the gust factor, the corresponding annualised percentage increase would likely be a maximum of 15%.

The annualised percentage increase in ground shear at sub-population 1c is predicted to be a maximum of around 10%. For the gust factor, a maximum annualised increase of just above 5% was predicted.

Note that ground shear and turbulence (gust factor) are not cumulative. If one increases by 10% and the other by 15%, this does not lead to a combined increase of 25%.

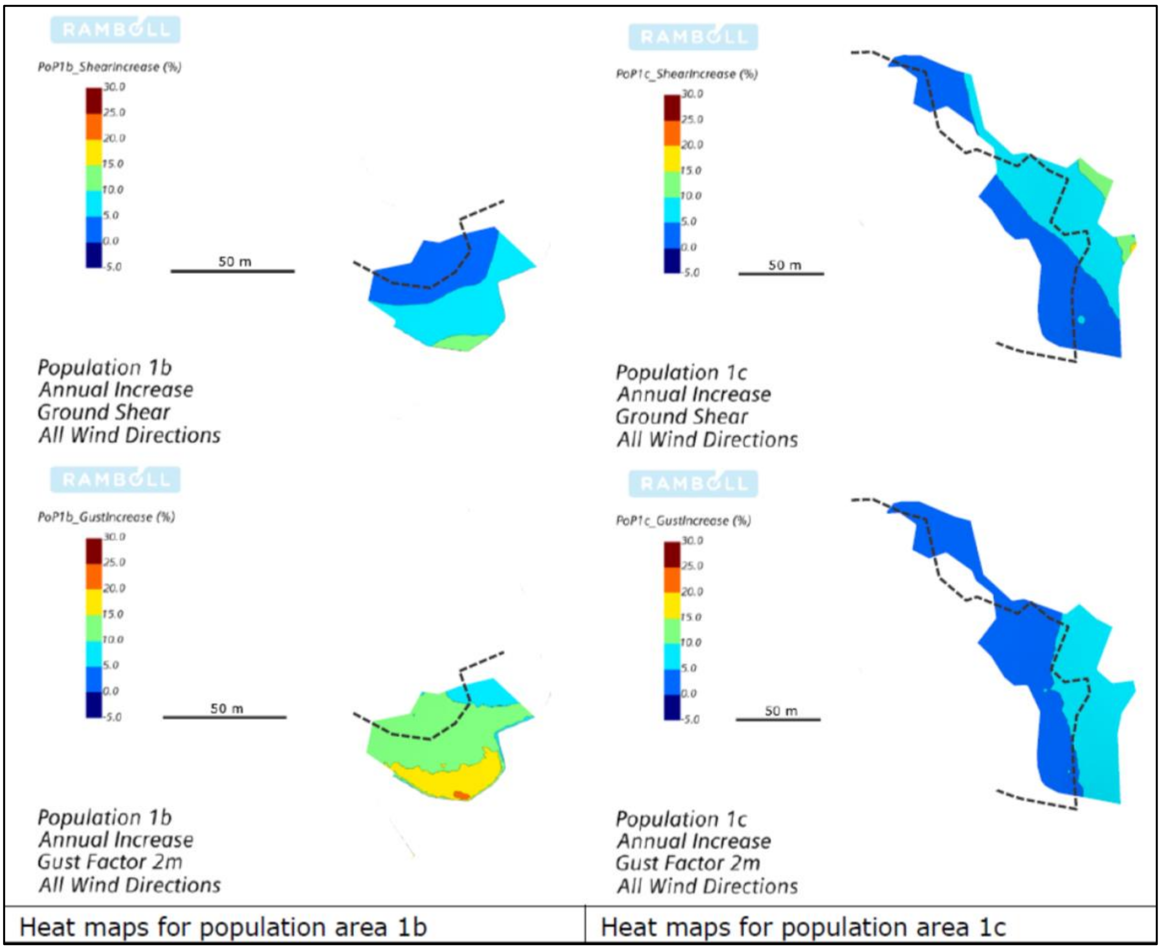


Figure 61: Annualised heat maps for changes in ground shear and gust factor for sub-populations 1b and 1c

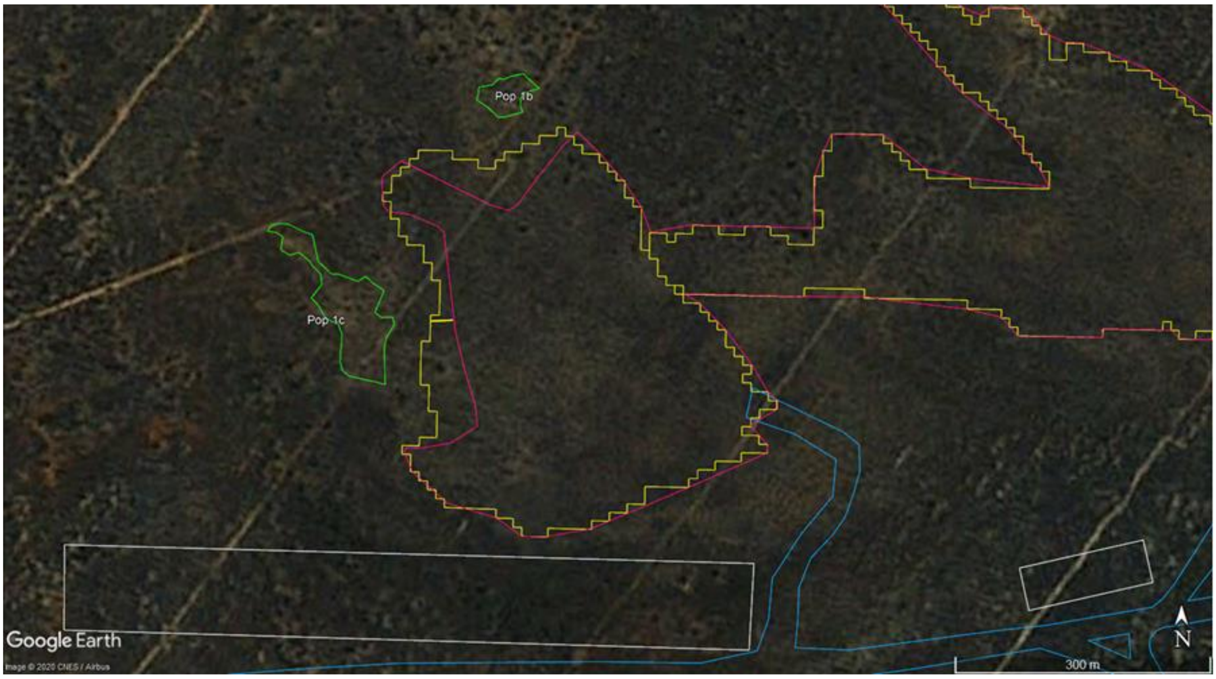


Figure 62: Comparison of modelled mine pit (yellow) and revised mine pit (red)

Summary

Audalia has increased the separation between mine pits and *M. aquilonaris* sub-populations 1b and 1c to minimise indirect impacts, and this has resulted in significant reductions in predicted increases in ground shear and wind gusts. Only subtle changes in wind shear (<10%) and gust factor (<15%) within *M. aquilonaris* sub-populations 1b and 1c are predicted to arise from the proposed mine pit, and wind flow over the sub-populations 1a, 1d and 1e are completely unchanged.

The marginal changes to wind speed would not be expected to affect rainfall or the partitioning of rainfall into runoff and infiltration within critical habitat. There will also be no change to solar radiation (as a key driver of temperature) inputs to the critical habitat. Air flowing over the pit can be expected to assume some of the characteristics of the temperature profile of the pit. Differences would be most significant at low wind speeds when thermal differences would be most pronounced. Subtle changes in temperature and humidity (i.e. an increase in temperature due to higher local radiative absorption from the sun, which would in principle lead to a lower relative humidity) would be expected. It is noted that the *M. aquilonaris* populations are all on north-facing slopes that will receive higher levels of solar radiation than surrounding areas. The sub-populations also have slightly more bare ground and rock outcrop than the surrounding vegetation (Botanica, 2019; Appendix 3.4), so some subtle changes in temperature and relative humidity may already occur between the sub-populations and surrounding vegetation.

Based on the above, the Proposal is not predicted to significantly alter the microclimate of the *M. aquilonaris* sub-populations such that the health or viability of the sub-populations are affected.

Changes to Hydrological Regimes

The Proposal has been revised to ensure that the Mine DE does not encroach into the upslope catchment of any current *M. aquilonaris* sub-populations (Figure 63). The Proposal will however result in the disturbance of 0.56 ha of the catchment above the optimal habitat for sub-population 1c (Figure 64). This equates to a 33% reduction in the 1.69 ha upslope catchment.

The reduction in the catchment is considered unlikely to reduce the viability of the optimal habitat, as the sub-populations for this species lie across catchment divides (Figure 63), indicating that the species is unlikely to be reliant on upslope surface water runoff for survival.

Mitigation measures are proposed to ensure that upslope surface water runoff is able to pass through the abandonment bund (Section 5.6).

Hydrocarbon or Saline Water Spills

M. aquilonaris occurs high in the catchment and therefore the only risk of hydrocarbon or saline water flowing into the critical habitat will be during vegetation clearing for a small portion of the Vesuvius mine pit, and the construction of the abandonment bund (Figure 58 and Figure 59 show these in cross section). Once overburden is removed the mine pit will begin to form a new catchment and will not flow into the critical habitat.

Audalia has committed to a number of mitigation measures for works conducted upslope of *M. aquilonaris* critical habitat (refer to Section 5.6). With the implementation of these controls it is unlikely that a hydrocarbon or saline water spill would enter *M. aquilonaris* critical habitat.

Unauthorised Access

The Proposal will increase the level of human activity in the area, and as such the risk of unauthorised access into *M. aquilonaris* sub-populations or habitat will increase. Audalia has committed to several mitigation measures to prevent unauthorised access for the life of the Proposal and ongoing if requested by DBCA (refer to Section 5.6).

Weeds

Weeds have the potential to outcompete and displace *M. aquilonaris* individuals if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site.

Minimal vegetation clearing works are proposed within the *M. aquilonaris* critical habitat boundary (1.51 ha) and as such the risk of introducing weeds is relatively low. However, given that nine weed species were recorded during by Botanica (2020c), and the conservation status of this species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with *M. aquilonaris* (Section 5.6).

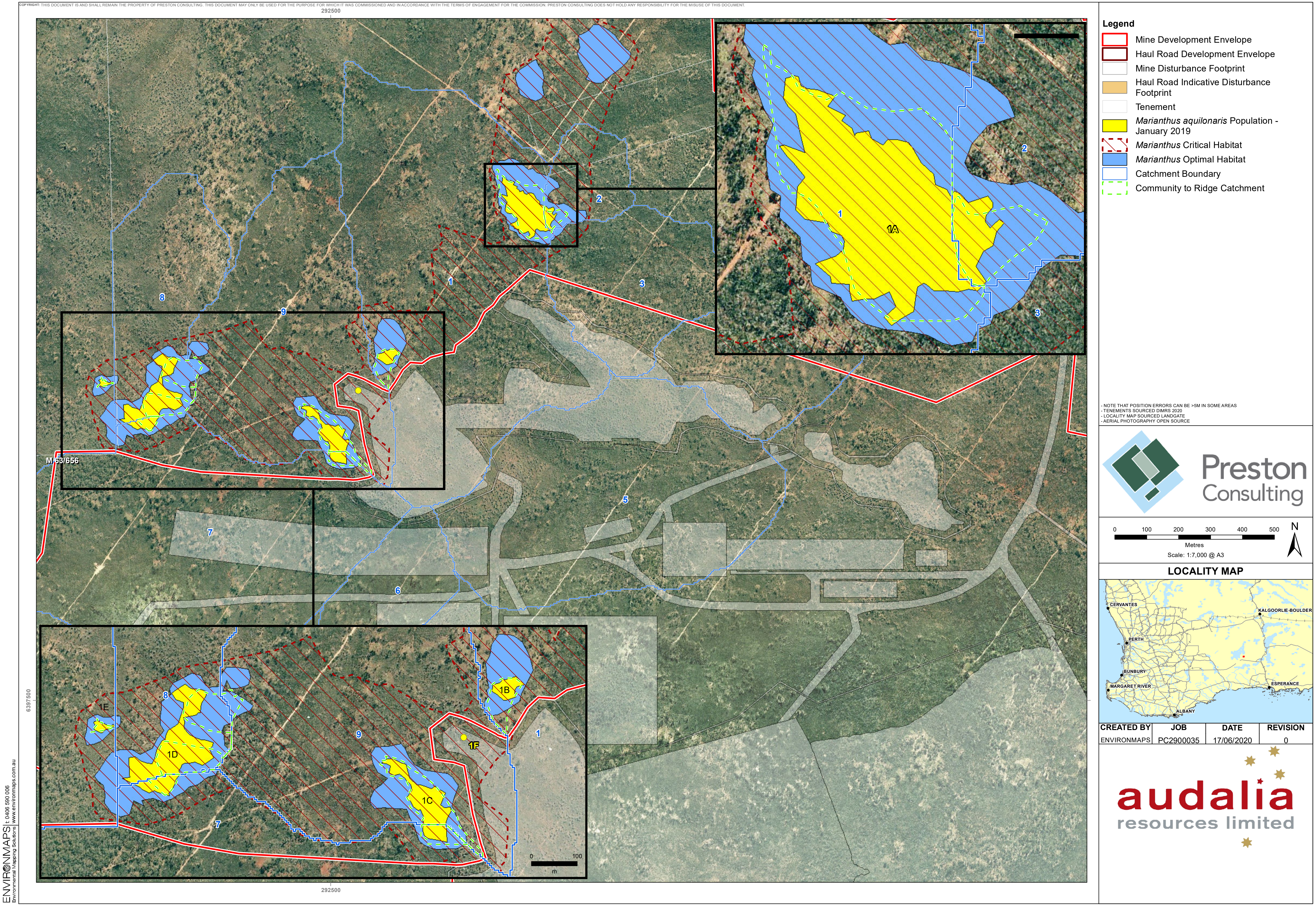


Figure 63: Area upslope of M. aquilonaris sub-populations

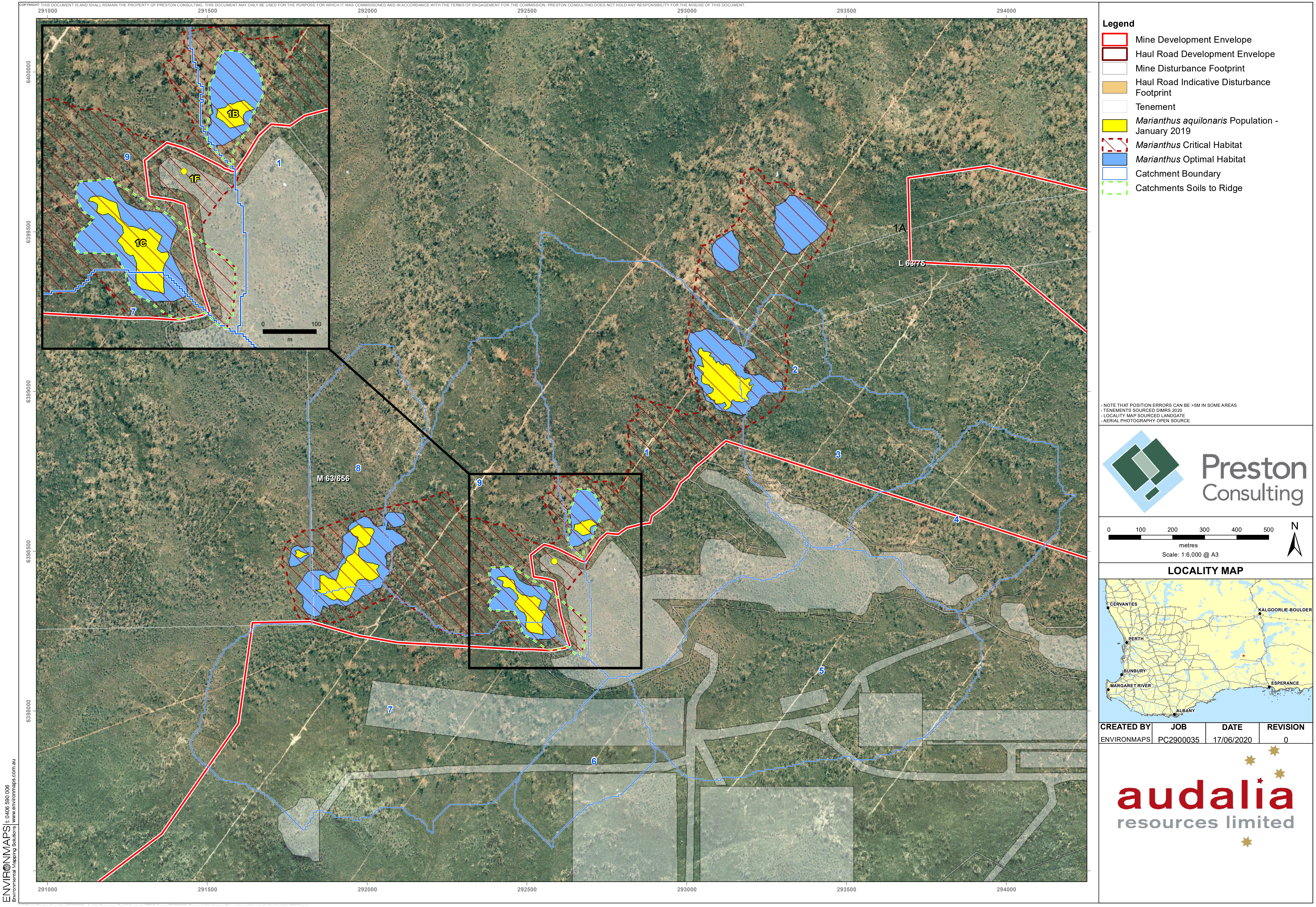


Figure 64: Proposal disturbance upslope of M. aquilonaris optimal habitat

Increased Fire Risk

Bushfires are often caused by lightning and are considered a natural part of the environment as they can assist with regeneration of some species and ecosystems, including *M. aquilonaris*, which is known to respond after fire events. Increased fire intensity and frequency can however impact *M. aquilonaris* and associated habitat.

Mining activities have the potential to ignite bushfires through hot work and other activities, however with appropriate firefighting and prevention management measures in place, the development of the Proposal will provide improved access to the region and improved ability to fight fire outbreaks and prevent them from spreading. The potential for increased fire risk is therefore expected to not be significant.

Pollinators

An assessment of impacts to insect species that may pollinate *M. aquilonaris* is provided in Section 6.5.3. The assessment identified that the Proposal may result in:

- A disturbance of 0.46 ha (8.7%) of the combined 5.28 ha extent of the *M. aquilonaris* sub-population 1b and associated 100 m buffer; and
- A disturbance of 0.77 ha (8.1%) of the combined 9.46 ha extent of the *M. aquilonaris* sub-population 1c and associated 100 m buffer.

Given there is more than 60 m and 70 m between the mine pit and sub-population 1b and 1c respectively it is likely that the pollinators that currently inhabit habitat within the proposed mine pit footprint visit these sub-populations infrequently in comparison to those within or close to the sub-populations. An abandonment bund (constructed from competent rock) will also lie between the mine pit and sub-population 1b and 1c however only 3 – 5 m of disturbance is required for this bund.

The Ramboll (2020a) modelling report predicted that the following pollinator habitat areas would experience dust deposition above 8 $g/m^2/month$ (Figure 65); the conservative impact value described in Section 5.5.1:

- 1.28 ha of sub-population 1b pollinator habitat. This equates to 24.2% of the combined 5.28 ha extent of the *M. aquilonaris* sub-population 1b and associated 100 m buffer; and
- 1.63 ha of sub-population 1c pollinator habitat. This equates to 17.2% of the combined 9.46 ha extent of the *M. aquilonaris* sub-population 1b and associated 100 m buffer.

The extent of the local native bee population is unknown, however the Proposal disturbance equates to an estimated maximum of 10% of the surrounding habitat when using various buffers under 3 km. Once buffers more than 3 km are used the disturbance percentage reduces significantly. A conservative estimate is therefore that 10% of the habitat utilised by the local native bee population may be disturbed by the Proposal.

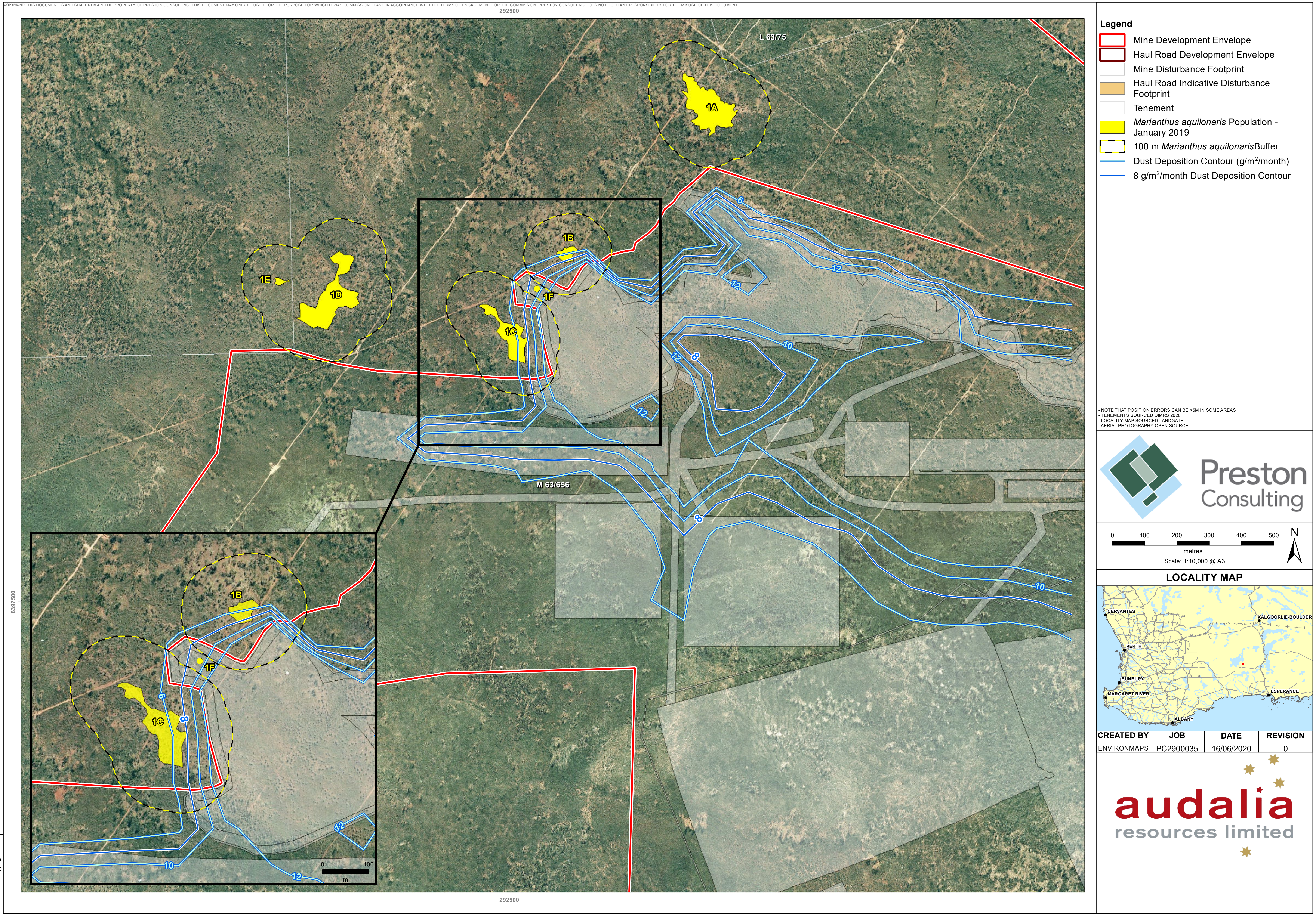


Figure 65: Maximum dust deposition within predicted pollinator range

Summary

Based on the assessments above, the Proposal is predicted to have the following potential impacts on *M. aquilonaris* that may be considered significant:

- The disturbance of 1.51 ha of sub-optimal habitat, which also forms part of the critical habitat for this species (i.e. all disturbance within critical habitat is limited to sub-optimal habitat). This disturbance equates to 2.87% of the total extent of sub-optimal habitat and 2.34% of the total extent of critical habitat;
- The disturbance of the potential seed bank in proximity to sub-population 1f;
- The potential loss of up to 0.95 ha of sub-optimal / critical habitat that lies within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure;
- Dust deposition impacts during Year 1 of mining to:
    - 2.71 ha of critical habitat, including:
        - Six individuals within sub-population 1b;
        - 0.01 ha of the area of occupancy of sub-population 1b;
        - 0.47 ha of optimal habitat of sub-population 1b and 1c; and
        - 2.24 ha of sub-optimal habitat;
    - 1.28 ha of sub-population 1b pollinator habitat; and
    - 1.63 ha of sub-population 1c pollinator habitat;
- The disturbance of pollinator habitat:
    - 0.46 ha (8.7%) of habitat for sub-population 1b;
    - 0.77 ha (8.1%) of habitat for sub-population 1c; and
    - Up to 10% of habitat for the surrounding local native bee population.

Several of the potential indirect impacts listed above overlap the same area, therefore the potential impacts of the Proposal are summarised as:

- **Direct disturbance** - 1.51 ha of sub-optimal / critical habitat, including the potential seed bank in proximity to sub-population 1f;
- **Indirect impacts**:
    - Potential reduction in the health of 0.47 ha of optimal / critical habitat potentially impacted (all of which is potential pollinator habitat), including 0.01 ha of the area of occupancy containing six individuals;
    - Health of 2.91 ha of sub-optimal / critical habitat potentially impacted (2.81 ha of which is potential pollinator habitat); and
    - An additional 0.2 ha of pollinator habitat that will be impacted by dust deposition.

The above assessment is based on the implementation of strict mitigation measures proposed in Section 5.6, designed to minimise these impacts as much as practicable.

5.5.3 *EUCALYPTUS RHOMBOIDEA*

Direct Disturbance

The Mine DE intersect two populations of *E. rhomboidea*, with 0.4 ha predicted to be disturbed by the Proposal. This equates to 3.3% of the 12 ha total local population (unburnt populations within 150 km of the Mine DE). The area to be disturbed contains 768 individuals of *E. rhomboidea*, representing 4.9% of the 15,606 known records in the local region (within 150 km of the Mine DE).

The Mine DE intersect 912 ha of critical habitat for *E. rhomboidea*, with 282 ha predicted to be disturbed by the Proposal. This includes 77 ha of optimal habitat and 205 ha of sub-optimal habitat. This equates to 3.1% of the total mapped extent of optimal habitat and 0.5% of the total mapped extent of sub-optimal habitat.

The disturbance will be required for the Vesuvius / Fuji mine pit and associated surrounding abandonment bund (Figure 66).

While this disturbance is a relatively small percentage of the individuals and population extent of this species, the significance of this disturbance is best assessed in context with indirect impacts. This assessment is provided in the summary at the end of Section 5.5.3.

Loss of Habitat due to Potential Mine Pit Wall Erosion

There is currently 0.2 ha of *E. rhomboidea* population extent and 225 individuals that lie between the mine pit and abandonment bund and will not be cleared (Figure 66). This area of the population lies within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure.

This equates to 1.7% of the 12 ha total local population (unburnt populations within 150 km of the Mine DE) and 1.4% of the 15,606 known records in the local region (within 150 km of the Mine DE).

Dust Deposition

The Ramboll (2020a) modelling report predicted that 370 *E. rhomboidea* individuals, 55.2 ha of optimal habitat and 16.6 ha of sub-optimal habitat would experience dust deposition above 8 $g/m^2/month$; the conservative impact value described in Section 5.5.1. These areas are shown on Figure 67.

Dust emissions from the Proposal may result in a reduction in the health of:

- 370 individuals, which represents 2.4% of the local population;
- 2.2% of optimal habitat; and
- 0.04% of sub-optimal habitat.

This is considered to be a conservative prediction given the impact value chosen for the assessment, however given the potential future conservation status of this species a conservative position is appropriate.

Changes to Hydrological Regimes

E. rhomboidea populations within or close to the Mine DE are located close to the top of the local catchments (Figure 68), and there are no defined drainage lines close to these populations within the Mine DE. The Proposal mine pits will however remove or reduce the size of the upslope catchment of these populations (Figure 68), which may result in less overland surface water flow through these populations. This reduction in overland flow may affect the health of up to 430 *E. rhomboidea* individuals across up to 0.6 ha of the sub-populations within the Mine DE.

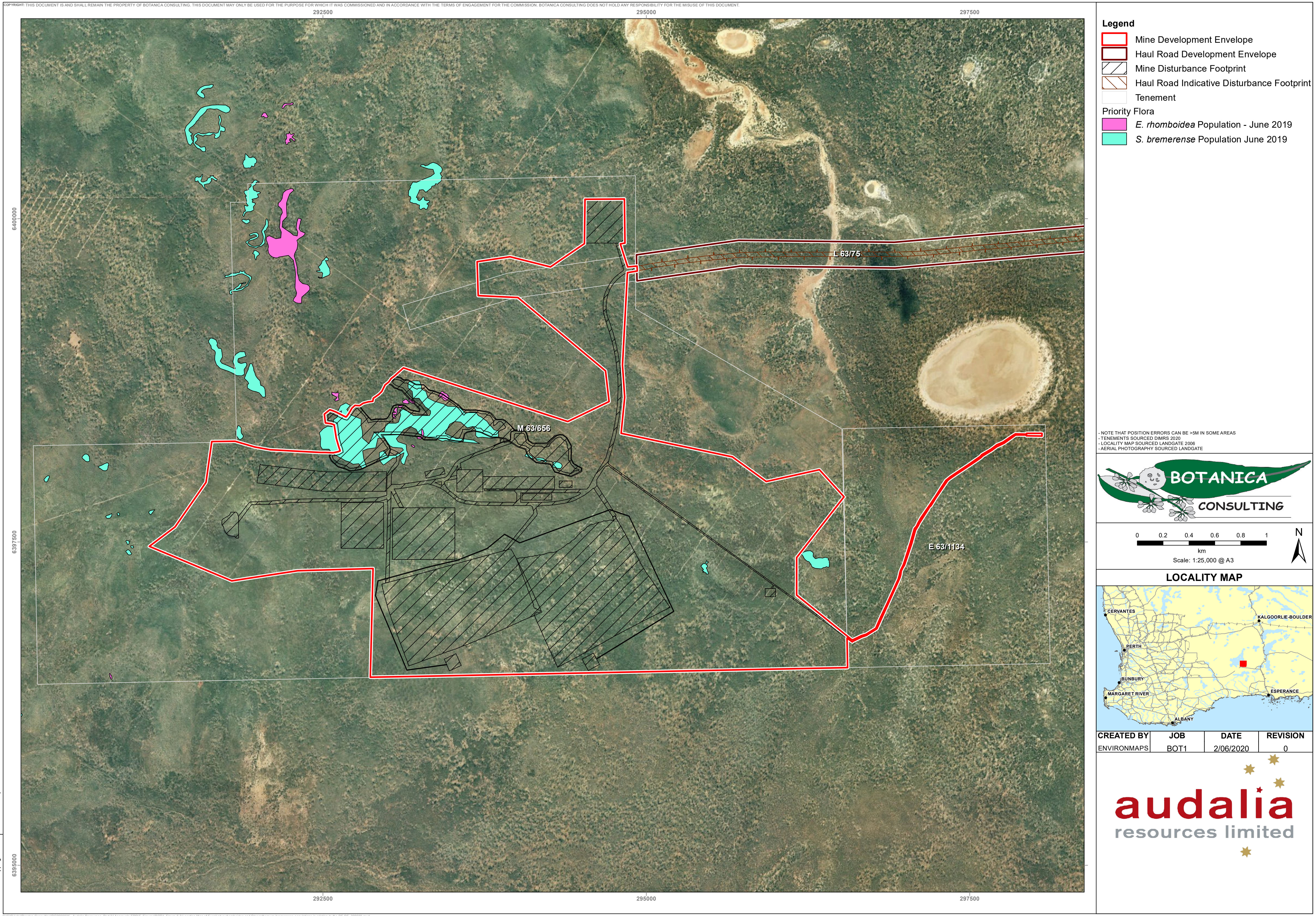


Figure 66: Eucalyptus rhomboidea and Stenanthemum bremerense populations within the Mine DE

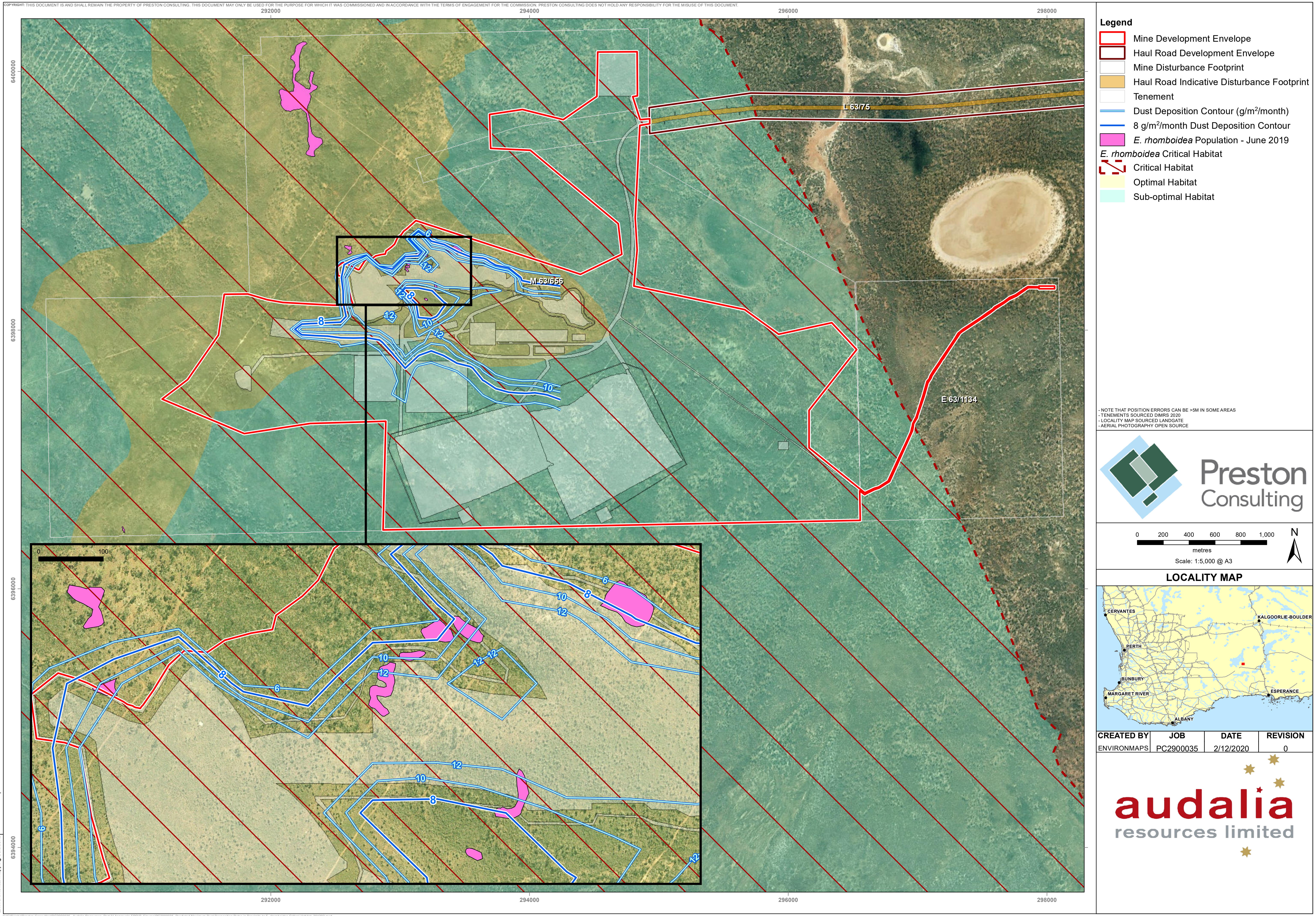


Figure 67: Predicted dust deposition in proximity to Eucalyptus rhomboidea populations and habitat

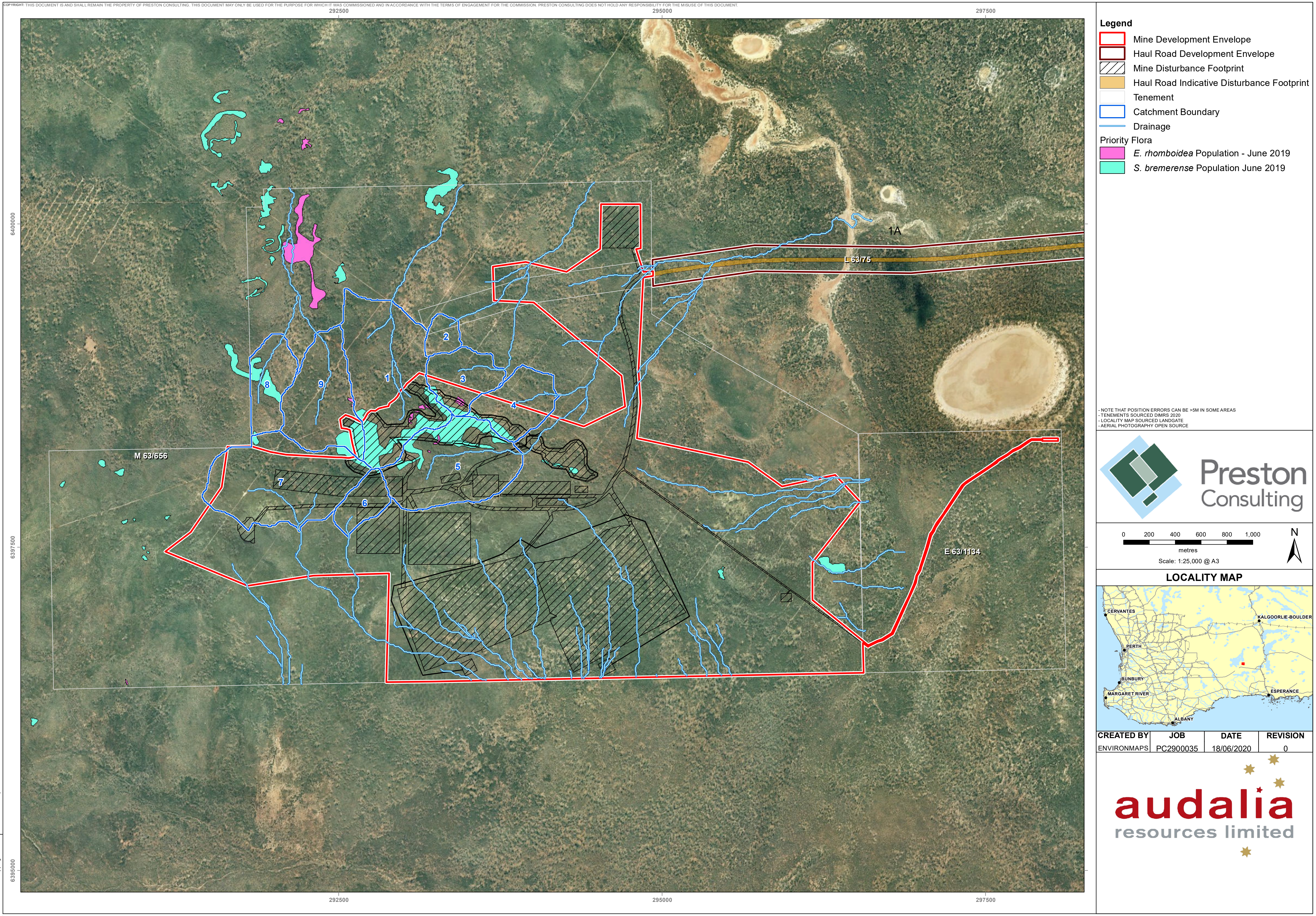


Figure 68: Drainage lines and catchments in proximity to Eucalyptus rhomboidea and Stenanthemum bremerense populations

Hydrocarbon or Saline Water Spills

E. rhomboidea occurs high in the catchment and therefore the only risk of hydrocarbon or saline water flowing into the critical habitat will be during vegetation clearing for a portion of the Vesuvius / Fuji mine pit, and the construction of the abandonment bund. Once overburden is removed the mine pit will begin to form a new catchment and will not flow into the *Eucalyptus rhomboidea* populations.

Audalia has committed to a number of mitigation measures for works conducted upslope of *E. rhomboidea* populations (refer to Section 5.6). With the implementation of these controls it is unlikely that a hydrocarbon or saline water spill would enter *Eucalyptus rhomboidea* populations.

Weeds

Weeds have the potential to outcompete and displace *E. rhomboidea* seedlings if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site.

Minimal vegetation clearing works are proposed within the *E. rhomboidea* populations (0.6 ha) and as such the risk of introducing weeds is relatively low. However, given that nine weed species were recorded during by Botanica (2020c), and the potential future conservation status of this species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with *E. rhomboidea* (Section 5.6).

Increased Fire Risk

Bushfires are often caused by lightning and are considered a natural part of the environment as they can assist with regeneration of some species and ecosystems. Increased fire intensity and frequency can however impact *E. rhomboidea* and associated habitat.

Mining activities have the potential to ignite bushfires through hot work and other activities, however with appropriate firefighting and prevention management measures in place, the development of the Proposal will provide improved access to the region and improved ability to fight fire outbreaks and prevent them from spreading or becoming too intense. The potential for increased fire risk is therefore expected to not be significant.

Summary

Based on the assessments above, the Proposal is predicted to have the following potential impacts on *E. rhomboidea* that may be considered significant:

- The disturbance of 0.4 ha of *E. rhomboidea* populations, which contain 768 individuals. This disturbance equates to 3.3% of the total extent of the local population and 4.9% of the known records in the local region;
- The potential loss of up to 0.2 ha of *E. rhomboidea* populations and 225 individuals that lie within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure;
- Dust deposition impacts during Year 1 of mining to 370 individuals, representing 2.4% of the local population;

- The reduction in overland flow to 0.6 ha of *E. rhomboidea* populations and 430 individuals, representing 5.0% of the total extent of the local population and 2.8% of the known records in the local region.

Several of the potential indirect impacts listed above overlap the same area, therefore the potential impacts of the Proposal are summarised as:

- **Direct disturbance** – 0.4 ha of *E. rhomboidea* populations, including 768 individuals; and
- **Indirect impacts** – Reduction in the health of 0.6 ha of *E. rhomboidea* populations, containing 1,198 individuals.

In total, 1 ha of *E. rhomboidea* population extent may be directly or indirectly impacted, equating to 8.33% of the local extent. These populations contain 1,198 individuals, equating to 7.67% of the local population.

The above assessment is based on the implementation of strict mitigation measures proposed in Section 5.6, designed to minimise these impacts as much as practicable.

A summary of the current conservation status of *E. rhomboidea* (under IUCN Criteria) and the Proposal impacts on conservation status is provided in Table 32. The assessment indicates that the Proposal will not increase the potential 'Endangered' status of *E. rhomboidea.*

Table 32: Assessment of impacts to *Eucalyptus rhomboidea* against IUCN Criteria

Listing Criteria	Current status	Proposal impacts
A. Population size reduction *(evidence of decline)*	There is currently insufficient quantitative information to assess against this criterion. However, based on available information it would appear *E. rhomboidea* would not currently meet Criterion A.	No change – the Proposal will result in ~5% reduction in population size which does not meet any of the Threatened Criteria
B. Geographic range *(EOO and AOO, number of locations and evidence of decline)*	Currently meets the criteria for Endangered B1 ab(iii,v) and B2 ab(iii,v)	No change from Endangered - Proposal will not reduce extent of occurrence below 100 km² or area of occupancy below 10 km² (Critically Endangered Criteria)
C. Small population size and decline *(population size, distribution and evidence of decline)*	There is currently insufficient information to meet Criterion C.	No change - Proposal will result in ~5% reduction in population size which does not meet any of the Threatened Criteria
D. Very small or restricted population *(population size)*	Meets the criteria for Vulnerable D2.	No change from Vulnerable - Proposal will not reduce number of mature individuals below 250 (Endangered Criteria)
E. Quantitative analysis *(statistical probability of extinction)*	Currently insufficient information to assess against criteria.	Currently insufficient information to assess against criteria.

5.5.4 *Stenanthemum bremerense*

Direct Disturbance

The Mine DE intersects three populations of *S. bremerense*, with 21 ha predicted to be disturbed by the Proposal. This equates to 37.3% of the 56 ha total local population (unburnt populations within 150 km of the Mine DE). The area to be disturbed contains 2,049 individuals of *Stenanthemum bremerense*, representing 5.1% of the 40,126 known records in the local region (within 150 km of the Mine DE).

The Mine DE intersects 924 ha of critical habitat for *S. bremerense*, with 284 ha predicted to be disturbed by the Proposal. This includes 263 ha of optimal habitat and 19 ha of sub-optimal habitat. This equates to 1.1% of the total mapped extent of optimal habitat and less than 0.01% of the total mapped extent of sub-optimal habitat.

The disturbance will be required for the mine pit and associated surrounding abandonment bund, as well as an access road to the mine pit (Figure 66).

The significance of this disturbance is best assessed in context with indirect impacts. This assessment is provided in the summary at the end of Section 5.5.4.

Loss of Habitat due to Potential Mine Pit Wall Erosion

There is currently 3 ha of *S. bremerense* population extent and 1,016 individuals that lie between the mine pit and abandonment bund and will not be cleared (Figure 66). This area of the population lies within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure.

This equates to 5.4% of the 56 ha total local population (unburnt populations within 150 km of the Mine DE) and 2.5% of the 40,126 known records in the local region (within 150 km of the Mine DE).

Dust Deposition

The Ramboll (2020a) modelling report predicted that 6.2 ha of the 56 ha local *S. bremerense* population extent (11.1%), containing 1,379 individuals, and 71.8 ha of optimal habitat would experience dust deposition above 8 $g/m^2/month$; the conservative impact value described in Section 5.5.1. These areas are shown on Figure 69.

Dust emissions from the Proposal may therefore result in a reduction in the health of these 1,379 individuals, which represent 3.4% of the local population, and 0.3% of the optimal habitat extent.

This is considered to be a conservative prediction given the impact value chosen for the assessment, however given the potential future conservation status of this species a conservative position is appropriate.

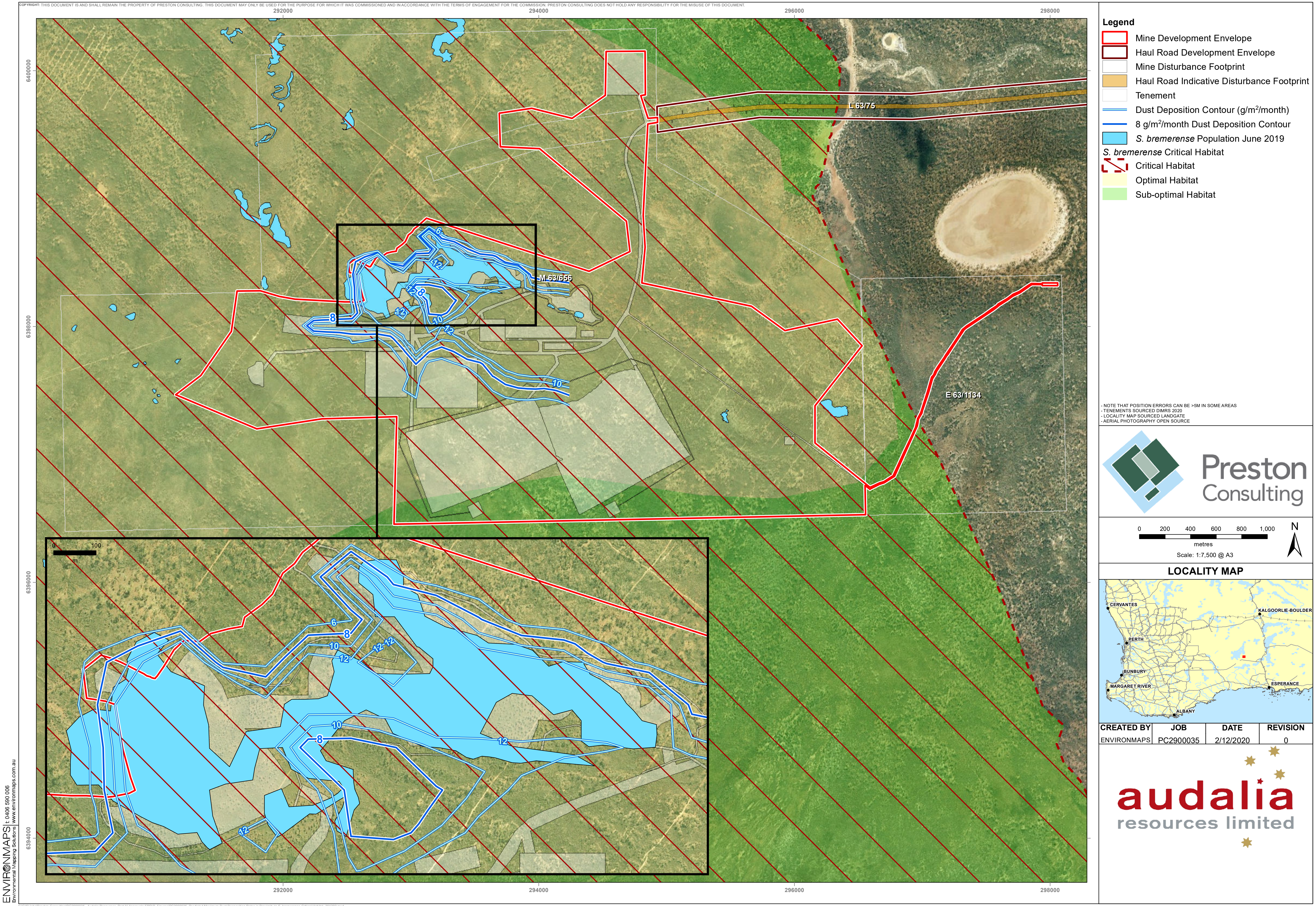


Figure 69: Predicted dust deposition in proximity to Stenanthemum bremerense populations and habitat

Changes to Hydrological Regimes

S. bremerense populations within or close to the Mine DE are located at the top of the local catchments (Figure 68), and there are no defined drainage lines close to these populations.

The Proposal mine pits will remove or reduce the size of the upslope catchment of some portions of these populations (Figure 68), however given the *S. bremerense* population lies on the catchment divide it is unlikely that the population relies on significant overland surface water flow. This reduction in overland flow is therefore considered unlikely to have a significant impact on the health of the remaining population.

Hydrocarbon or Saline Water Spills

The *S. bremerense* populations that occur close to the Proposal lie high in the catchment and therefore the only risk of hydrocarbon or saline water flowing into the critical habitat will be during vegetation clearing for the adjacent Vesuvius / Fuji mine pit, and the construction of the abandonment bund. Once overburden is removed the mine pit will begin to form a new catchment and drainage will no longer flow into the *S. bremerense* populations.

Audalia has committed to a number of mitigation measures for works conducted upslope of *S. bremerense* populations (refer to Section 5.6). With the implementation of these controls it is unlikely that a hydrocarbon or saline water spill would enter *S. bremerense* populations.

Weeds

Weeds have the potential to outcompete and displace *S. bremerense* individuals if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site.

An estimated 21 ha of vegetation clearing works are proposed within the *S. bremerense* populations and as such there is a moderate risk of introducing weeds. Given that nine weed species were recorded during by Botanica (2020c), and the potential future conservation status of this species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with *S. bremerense* (Section 5.6).

Increased Fire Risk

Bushfires are often caused by lightning and are considered a natural part of the environment as they can assist with regeneration of some species and ecosystems. Increased fire intensity and frequency can however impact *S. bremerense* and associated habitat.

Mining activities have the potential to ignite bushfires through hot work and other activities, however with appropriate firefighting and prevention management measures in place, the development of the Proposal will provide improved access to the region and improved ability to fight fire outbreaks and prevent them from spreading or becoming too intense. The potential for increased fire risk is therefore expected to not be significant.

Summary

Based on the assessments above, the Proposal is predicted to have the following potential impacts on *S. bremerense* that may be considered significant:

- The disturbance of 284 ha of critical habitat, including 21 ha of *S. bremerense* population extent, which contain 2,049 individuals, 263 ha of optimal habitat and 19 ha of sub-optimal habitat. This disturbance equates to 37.3% of the total extent of the local population, 5.1% of the known records in the local region, 1.1% of the total mapped extent of optimal habitat and less than 0.01% of the total mapped extent of sub-optimal habitat;
- The potential loss of up to 3 ha of *S. bremerense* population and 1,016 individuals that lie within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure; and
- Dust deposition impacts predominantly during Year 1 of mining to 6.2 ha of *S. bremerense* population extent, representing 11.1% of the local extent, containing 1,379 individuals, representing 3.4% of the local population, and 0.3% of optimal habitat extent.

Several of the potential indirect impacts listed above overlap the same area, therefore the potential impacts of the Proposal are summarised as:

- **Direct disturbance** – 21 ha of *S. bremerense* populations, including 2,049 individuals, 263 ha of optimal habitat and 19 ha of sub-optimal habitat; and
- **Indirect impacts** – Reduction in health of 6.2 ha of *S. bremerense* populations, containing 1,379 individuals, and 0.3% of optimal habitat extent.

In total, 27.2 ha of *S. bremerense* population extent may be directly or indirectly impacted; 48.6% of the local extent. These populations contain 3,428 individuals, equating to 8.5% of the local population.

The above assessment is based on the implementation of strict mitigation measures proposed in Section 5.6, designed to minimise these impacts as much as practicable.

A summary of the current conservation status of *S. bremerense* (under IUCN Criteria) and the Proposal impacts on conservation status is provided in Table 32. The assessment indicates that the Proposal will not increase the potential 'Endangered' status of *S. bremerense.*

Table 33: Assessment of impacts to *Eucalyptus rhomboidea* against IUCN Criteria

Listing Criteria	Current status	Proposal impacts
A. Population size reduction *(evidence of decline)*	There is currently insufficient quantitative information to assess against this criterion. However, based on available information it would appear *S. bremerense* would not currently meet Criterion A.	No change – the Proposal will result in ~8% reduction in population size which does not meet any of the Threatened Criteria
B. Geographic range *(EOO and AOO, number of locations and evidence of decline)*	There is currently insufficient quantitative information to assess against this criterion. However, based on available information it would appear *S. bremerense* would not currently meet all the requirements of Criterion B.	Proposal will have minimal impact on extent of occurrence or area of occupancy. Currently 25 known populations, only two of which are proposed to be impacted.
C. Small population size and decline *(population size, distribution and evidence of decline)*	There is currently insufficient information to meet Criterion C.	No change - Proposal will result in ~8% reduction in population size which does not meet any of the Threatened Criteria

Listing Criteria	Current status	Proposal impacts
D. Very small or restricted population *(population size)*	Based on available information it would appear *S. bremerense* would not currently meet Criterion A.	No change - Proposal will not reduce number of mature individuals below 1,000 (Vulnerable Criteria), Area of Occupancy will remain above 20 km^2 and number of locations will not be reduced below 5.
E. Quantitative analysis *(statistical probability of extinction)*	Currently insufficient information to assess against criteria.	Currently insufficient information to assess against criteria.

5.5.5 Other Priority Flora

Direct Disturbance

The DEs contain five other Priority Flora species, and three species are predicted to be directly disturbed by the Proposal:

- *Acacia mutabilis* subsp. *stipulifera* (P3);
- *Hakea pendens* (P3); and
- *Teucrium diabolicum* (P3).

An estimated 10,001 *Acacia mutabilis* subsp. *stipulifera* individuals are predicted to be disturbed, which equates to 2.9% of the local population of 348,452. The disturbance will be predominantly required for the haul road (Figure 70), which represents a relatively narrow linear disturbance, and records are spread along a large extent of the Haul Road Study Area, indicating a relatively wide local distribution.

An estimated 876 *Hakea pendens* individuals are predicted to be disturbed, which equates to 12.9% of the local population of 6,783. The disturbance will be required within the Mine DE, primarily within the mine pits, as infrastructure has been located to minimise the disturbance of Priority Flora (Figure 71).

An estimated 1,150 *Teucrium diabolicum* individuals are predicted to be disturbed, which equates to 7.1% of the local population of 16,153. The disturbance will be required within both the Mine DE and the far western portion of the Haul Road DE. Infrastructure has been located to minimise the disturbance of this species, with disturbance limited to three separate locations (Figure 72).

The significance of the disturbance described above is best assessed in context with indirect impacts. This assessment is provided in the summary at the end of Section 5.5.5.

Loss of Habitat due to Potential Mine Pit Wall Erosion

There is currently 234 *Hakea pendens* individuals that lie between the mine pit and abandonment bund and will not be cleared (Figure 71). This area of the population lies within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure.

This equates to 3.4% of the 6,783 known records in the local region (within 150 km of the Mine DE).

Dust Deposition

The Ramboll (2020a) modelling report predicted that 364 *Hakea pendens* individuals would experience dust deposition above 8 g/m^2/month; the conservative impact value described in Section 5.5.1. These areas are shown on Figure 71. No other Priority Flora other than *E. rhomboidea* and *S. bremerense* are predicted to be impacted by dust deposition from the Proposal (these Priority Flora are discussed in Section 5.5.3 and 0 respectively)

Dust emissions from the Proposal may result in a reduction in the health of these 364 *Hakea pendens* individuals, which represent 5.4% of the local population. This is considered to be a conservative prediction given the impact value chosen for the assessment (refer to Section 5.5.1 for background on the impact value), however given the conservation status of this species a conservative position is appropriate.

Changes to Hydrological Regimes

Section 9 (Inland Waters) provides an assessment of the potential impacts of the Proposal on surface water regimes within the Mine and Haul Road DEs. The findings of those assessments is summarised below as applicable to impacts to Priority Flora.

Several drainage lines will be intersected by mining operations (Figure 109), with diversions proposed at the TSF, evaporation ponds and Pinatubo pit (Figure 3). These diversions are high in the catchment and will be engineered structures designed to allow the majority of the flows to be maintained. As such the impact to downstream vegetation is likely to be minor.

The location and route of the haul road, incorporation of natural drainage considerations into road design, the scale and frequency of drainage features and runoff events means that the extent of disruption to surface flows is not expected to be significant. The proposed monitoring, maintenance and retro-fitting of improved drainage where required will further reduce the frequency and consequence of any impacts to surface drainage (Section 9).

Based on the above it is unlikely that the Proposal would impact hydrological regimes to an extent that Priority Flora downstream or upstream of the Proposal would be significantly affected.

Weeds

Weeds have the potential to outcompete and displace the Priority Flora recorded within the DEs if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site.

Given that nine weed species were recorded during by Botanica (2020c), and the conservation status of the flora species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with Priority Flora (Section 5.6).

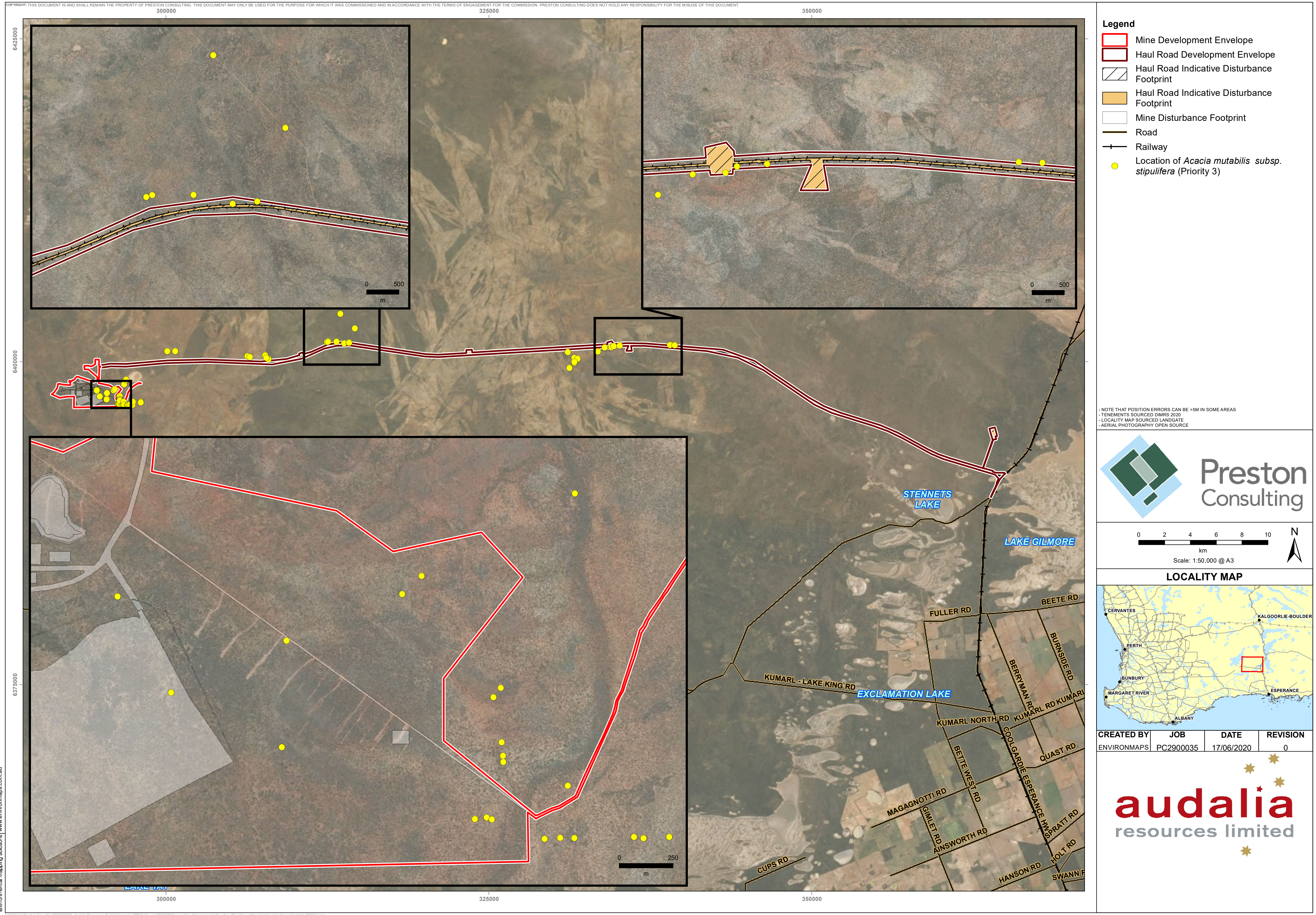


Figure 70: Acacia mutabilis subsp. stipulifera records within indicative disturbance footprint

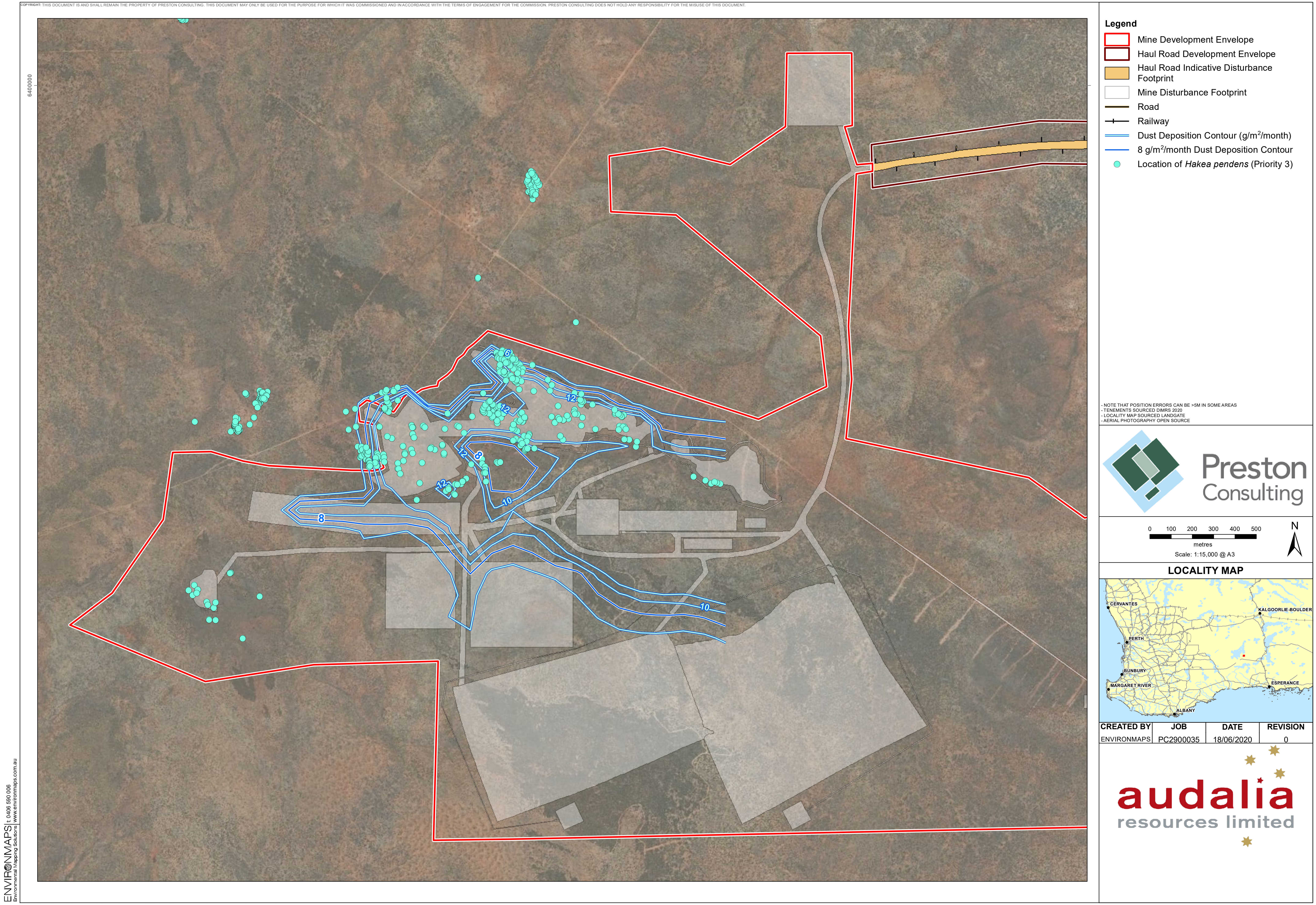


Figure 71: Hakea pendens records within indicative disturbance footprint

Figure 72: Teucrium diabolicum records within indicative disturbance footprint

Hydrocarbon or Saline Water Spills

Considering the hydrocarbon use described in Section 8.5.6, and the small scale of operations planned for the Proposal, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon contaminated soil that can be remediated via passive means such as bioremediation. Proposed control measures are identified in Section 9 and are designed to further reduce the risk of flora impacts from hydrocarbon spillage.

Saline water pipelines will run from the borefield to the RO Plant, then from the RO Plant to the evaporation ponds. A rupture of these pipelines has the potential to release saline water into the surrounding vegetation if it were to occur. There are very few Priority Flora records in proximity or downslope of these pipelines. Nevertheless, leak detection is proposed for these pipelines, which will trigger an automatic shut-down of the borefield or RO Plant feed. This will restrict the volume of saline water that would be released into the surrounding environment. Audalia will also investigate the option of containing a spill if it was to occur, by placing the pipes in a system of bunds and sumps designed to contain spillage. This option however may not be pursued along the whole length of the pipelines as the area of vegetation likely to be affected by a spill may be less than the clearing required to develop this containment infrastructure. The details of these systems are generally planned and managed via a Works Approvals under Part V of the EP Act (for the RO Plant, evaporation ponds and Process Plant) and a Mining Proposal under the Mining Act. Additional mitigation measures are proposed in Section 9 to minimise the change and potential impact of a saline water pipeline spill on Priority Flora.

Increased Fire Risk

Bushfires are often caused by lightning and are considered a natural part of the environment as they can assist with regeneration of some species and ecosystems. Increased fire intensity and frequency can however impact Priority Flora and associated habitat.

Mining activities have the potential to ignite bushfires through hot work and other activities, however with appropriate firefighting and prevention management measures in place, the development of the Proposal will provide improved access to the region and improved ability to fight fire outbreaks and prevent them from spreading or becoming too intense. The potential for increased fire risk is therefore expected to not be significant.

Summary

Based on the assessments above, the Proposal is predicted to result in the following potential impacts on Priority Flora:

- The disturbance of 10,001 *Acacia mutabilis* subsp. *Stipulifera* (P3) individuals, which equates to 2.9% of the local population;
- The disturbance of 876 *Hakea pendens* (P3) individuals, which equates to 12.9% of the local population;
- The disturbance of 1,150 *Teucrium diabolicum* (P3) individuals, which equates to 7.1% of the local population;

- The potential loss of up to 234 ha *Hakea pendens* individuals that lie within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure; and
- Dust deposition impacts during Year 1 of mining to 364 ha *Hakea pendens* individuals.

The potential indirect impacts to *Hakea pendens* listed above overlap the same area, therefore the potential impacts of the Proposal on this species are summarised as:

- **Direct disturbance** – 876 *Hakea pendens* individuals; and
- **Indirect impacts** – potential reduction in the health of 364 ha *Hakea pendens* individuals.

In total, up to 1,240 *Hakea pendens* individuals may be directly or indirectly impacted, equating to 18.3% of the local population.

Botanica located *Hakea pendens* across four different vegetation types. It was highly common (2,100 individuals across 545 locations) during the surveys undertaken by Botanica and has been found to be much more widespread than originally thought. 4,683 individuals have been recorded outside the survey area, including records within the Jilbadji Nature Reserve.

The above assessment is based on the implementation of strict mitigation measures proposed in Section 5.6, designed to minimise these impacts as much as practicable. With the implementation of these controls the potential impacts on other Priority Flora are not considered significant.

5.5.6 Proposed Bremer Range Nature Reserve

Direct Disturbance

Approximately 309 ha of the proposed native vegetation disturbance for the Proposal will occur within the boundaries of the proposed Bremer Range Nature Reserve. This equates to 0.6% of the 50,920 ha proposed for the Nature Reserve.

The proposal to create the Bremer Range Nature Reserve has yet to be enacted by Government, and it is not listed under the EPA Red Book recommendations for Conservation Reserves 1975-1993. Hopper and Nicole (2007) stated that a key reason for the Nature Reserve not being enacted was due to mineral prospectivity.

Mining as an activity is not incompatible with Nature Reserves (Environmental Defender's Office of WA, 2011), however proposed mining activities are appropriately subjected to greater scrutiny throughout their approvals processes if they are within a Nature Reserve. Strict management of environmental impacts such as weeds and waste also needs to be implemented throughout construction and operation to ensure that the values of the Nature Reserve is not impacted.

No other significant disturbance has occurred to-date within the proposed Bremer Range Nature Reserve, with the Emily Ann / Maggie Hays mining operations outside the boundary of this proposed reserve.

Loss of Habitat due to Potential Mine Pit Wall Erosion

An estimated 13 ha of vegetation lies between the mine pit and abandonment bund and will not be cleared. This vegetation lies within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure.

This equates to 0.03% of the extent of the proposed Bremer Range Nature Reserve.

Dust Deposition

The Ramboll (2020a) modelling report predicted that 80 ha of the proposed Bremer Range Nature Reserve would experience dust deposition above 8 g/m^2/month; the conservative impact value described in Section 5.5.1. Dust emissions from the Proposal may result in a reduction in the health within this area, which represents 0.2% of the 50,920 ha proposed for the Nature Reserve. This is considered to be a conservative prediction given the impact value chosen for the assessment (refer to Section 5.5.1 for background on the impact value).

Changes to Hydrological Regimes

Section 9.5 provides a detailed assessment of the impact of the Proposal on hydrological regimes. Several drainage lines will be intersected by the Proposal within the proposed nature reserve (Figure 109), with diversions proposed at the TSF, evaporation ponds, Pinatubo pit, and along the haul road (Figure 3). These diversions are high in each catchment and will be engineered structures designed to allow the majority of the flows to be maintained. As such the impact to downstream surface water regimes are likely to be minor.

Treated Sewage Disposal, Hydrocarbon and Saline Water Spills

Section 5.5.1 provides an assessment of the potential impacts of treated sewage disposal, and hydrocarbon and saline water spills. This assessment will apply to the proposed Bremer Range Nature Reserve as the majority of the impact sources lie within the proposed reserve boundary (i.e. wastewater treatment plant, mining operations, and saline water usage).

Weeds and Increased Fire Risk

Section 5.5.1 provides an assessment of the potential impacts of weeds and increased fire risks on the general vegetation surrounding the Proposal. This assessment will apply to the proposed Bremer Range Nature Reserve, as will the proposed mitigation measures in Section 9.5.

Summary

The Proposal is predicted to result in the disturbance of 309 ha of native vegetation within the proposed Bremer Range Nature Reserve, and potentially affect the health of up to 80 ha of surrounding vegetation from erosion or dust deposition impacts. The combined impact equates to 0.8% of the extent of the proposed Bremer Range Nature Reserve. Strict mitigation measures proposed in Section 5.6 are expected to be sufficient to ensure other potential indirect impacts do not have a significant impact on vegetation within the proposed Bremer Range Nature Reserve.

Based on the assessment provided in the sections above, the Proposal may result in an impact on the values of the proposed Bremer Range Nature Reserve, however it is expected to be relatively minor in scale due to the following reasons:

- A relatively modest disturbance of approximately 309 ha is required within the boundary of the proposed Bremer Range Nature Reserve (0.6% of its total extent);
- A conservative estimate of 80 ha of dust deposition impacts are predicted within the boundary of the proposed Bremer Range Nature Reserve (0.2% of its total extent);

- Minimal cumulative disturbance impacts exist; only a small amount of disturbance currently exists or is approved within the proposed Bremer Range Nature Reserve;
- Mitigation of indirect impacts (Section 5.6) are well understood in the mining industry (i.e. weed control, dust suppression, spill management); and
- Appropriate closure and rehabilitation is a requirement of the Mining Act.

5.5.7 Bremer Range Vegetation Complexes PEC

Direct Disturbance

Approximately 285 ha of the proposed native vegetation disturbance for the Proposal will occur within the boundaries of the Bremer Range Vegetation Complexes PEC. This equates to 0.3% of the mapped 88,150 ha extent of this PEC.

The only other significant disturbance that has occurred to-date within the Bremer Range Vegetation Complexes PEC is the Emily Ann / Maggie Hays mining operations, with an estimated 202 ha of disturbance. None of the vegetation communities identified at the Proposal are present at the Emily Ann / Maggie Hays mine, therefore cumulative disturbance is not relevant when assessing the vegetation communities that make up this PEC.

The cumulative direct disturbance of both the Proposal and the Emily Ann / Maggie Hays mining operations is 487 ha, or 0.6% of the mapped 88,150 ha extent of this PEC.

Dust Deposition

The Ramboll (2020a) modelling report predicted that 67 ha of the Bremer Range Vegetation Complexes PEC would experience dust deposition above 8 g/m^2/month; the conservative impact value described in Section 5.5.1. Dust emissions from the Proposal may result in a reduction in the health within this area, which represents 0.08% of the 88,150 ha extent of this PEC. This is considered to be a conservative prediction given the impact value chosen for the assessment (refer to Section 5.5.1 for background on the impact value).

Changes to Hydrological Regimes

Section 9.5 provides a detailed assessment of the impact of the Proposal on hydrological regimes. Several drainage lines will be intersected by the Proposal within the Bremer Range Vegetation Complexes PEC (Figure 109), with diversions proposed at the TSF, evaporation ponds and Pinatubo pit (Figure 3). These diversions are high in each catchment and will be engineered structures designed to allow the majority of the flows to be maintained. As such the impact to downstream surface water regimes are likely to be minor and unlikely to affect downstream vegetation.

Treated Sewage Disposal, Hydrocarbon and Saline Water Spills

Section 5.5.1 provides an assessment of the potential impacts of treated sewage disposal, and hydrocarbon and saline water spills. This assessment will apply to the proposed Bremer Range Vegetation Complexes PEC as the majority of the impact sources lie within the proposed reserve boundary (i.e. wastewater treatment plant, mining operations, and saline water usage).

Weeds and Increased Fire Risk

Section 5.5.1 provides an assessment of the potential impacts of weeds and increased fire risks on the general vegetation surrounding the Proposal. This assessment will apply to the proposed Bremer Range Vegetation Complexes PEC, as will the proposed mitigation measures in Section 5.6.

Summary

The Proposal is predicted to result in the disturbance of 292 ha of native vegetation within the Bremer Range Vegetation Complexes PEC, and potentially affect the health of up to 67 ha of surrounding vegetation from dust deposition impacts. Including the disturbance from Emily Ann / Maggie Hays mining operations, the combined cumulative impact equates to 0.6% of the extent of the Bremer Range Vegetation Complexes PEC. Strict mitigation measures proposed in Section 5.6 are expected to be sufficient to ensure other potential indirect impacts do not have a significant impact on vegetation within the Bremer Range Vegetation Complexes PEC.

Based on the assessment provided in the sections above, the Proposal may result in an impact on the values of the Bremer Range Vegetation Complexes PEC, however it is expected to be relatively minor in scale due to the following reasons:

- A relatively modest disturbance of approximately 285 ha is required within the boundary of the Bremer Range Vegetation Complexes PEC (0.3% of its total extent);
- A conservative estimate of 67 ha of dust deposition impacts are predicted within the boundary of the Bremer Range Vegetation Complexes PEC (0.08% of its total extent);
- Minimal cumulative disturbance impacts exist - 202 ha of disturbance is estimated to have occurred at the Emily Ann / Maggie Hays mining operations (0.2% of its total extent);
- Mitigation of indirect impacts (Section 5.6) are well understood in the mining industry (i.e. weed control, dust suppression, spill management); and
- Appropriate closure and rehabilitation are a requirement of the Mining Act.

5.5.8 Locally Significant Vegetation

Eight floristic communities occur within the Bremer Range Vegetation Complexes PEC and are considered to be significant vegetation as they resemble the floristic values of this PEC (refer to Section 5.3.7). Of these, six occur within the DEs and are predicted to be directly or indirectly impacted by the Proposal (Figure 48). One of these (HS-MWS1) is also significant as it provides habitat for *M. aquilonaris*.

Table 34 summarises the extent of the potential direct and indirect impacts on locally significant vegetation.

Table 34: Potential impacts on locally significant vegetation

Floristic Community	Extent in Study Area (ha)	Extent in Development Envelope (ha)	Extent in Disturbance Footprint (ha)	Indirect erosion impacts (ha)	Indirect dust impacts (ha)	Cumulative impacts (ha) (% of regional extent)
CLP-EW1	10,022	1,237	279	2	17	296 (3.0%)
CLP-MWS1	1,975	464	144	2	59	203 (10.3%)
CLP-MWS2	2,561	234	54	0	0	54 (2.1%)

Floristic Community	Extent in Study Area (ha)	Extent in Development Envelope (ha)	Extent in Disturbance Footprint (ha)	Indirect erosion impacts (ha)	Indirect dust impacts (ha)	Cumulative impacts (ha) (% of regional extent)
HS-EW1	15	5	1	0	1	2 (13.3%)
HS-MWS1	150	63	30	7	50	80 (53.3%)
HS-MWS2	16	0	0	0	0	0
HS-MWS3	96	0	0	0	0	0
HS-OS1	412	167	36	0	14	50 (12.1%)

Direct Disturbance

The Proposal will result in the disturbance of 544 ha of locally significant vegetation. This disturbance however equates to less than 20% of the mapped extent of any locally significant floristic community, with the greatest being 30 ha of HS-MWS1 (20% of mapped extent). Given that more than 80% of every floristic community will remain, when assessed in isolation the Proposal disturbance is unlikely to have a significant impact on locally significant vegetation. It is noted however that indirect impacts may also have a cumulative impact on locally significant vegetation, therefore the assessment of significance is best assessed with these indirect impacts taken into consideration. Refer to the summary at the end of this section for this assessment.

Loss of Habitat due to Potential Mine Pit Wall Erosion

An estimated 11 ha of locally significant vegetation lies between the mine pit and abandonment bund and will not be cleared:

- 2 ha within CLP-EW1, representing 0.02% of the mapped extent;
- 2 ha within CLP-MWS1, representing 0.1% of the mapped extent; and
- 7 ha within HS-MWS1, representing 4.7% of the mapped extent.

This vegetation lies within the zone of instability of the mine pit, which means that there is a risk that some of this area will erode at some stage after closure.

Dust Deposition

An estimated 141 ha of vegetation within the Mine DE is predicted to experience maximum dust deposition rates of more than 8 g/m^2/month and therefore may experience some health impacts during some periods during mining (most likely in Year 1). The potentially impacted area is at its maximum in Year 1 (Figure 52) and will reduce significantly after Year 1 (Figure 53). An additional 35 ha of vegetation within the Haul Road DE is predicted to experience maximum dust deposition rates of more than 8 g/m^2/month (Figure 56) and therefore may experience some health impacts during the operational period of the Proposal.

Five floristic communities are predicted to be impacted (listed as indirect impacts in Table 34 and shown in Figure 55), with HS-MWS1 the only unit predicted to have more than 10% of its mapped extent impacted.

Changes to Hydrological Regimes

Section 9 (Inland Waters) provides an assessment of the potential impacts of the Proposal on surface water regimes within the Mine and Haul Road DEs. The findings of those assessments are summarised below as applicable to impacts to locally significant vegetation.

Several drainage lines will be intersected by mining operations (Figure 109), with diversions proposed at the TSF, evaporation ponds and Pinatubo pit (Figure 3). These diversions are high in the catchment and will be engineered structures designed to allow the majority of the flows to be maintained. As such the impact to downstream vegetation is likely to be minor.

The location and route of the haul road, incorporation of natural drainage considerations into road design, the scale and frequency of drainage features and runoff events means that the extent of disruption to surface flows is not expected to be significant. The proposed monitoring, maintenance and retro-fitting of improved drainage where required will further reduce the frequency and consequence of any impacts to surface drainage (Section 0).

Based on the above it is unlikely that the Proposal would impact hydrological regimes to an extent that downstream or upstream locally significant vegetation would be significantly affected.

Treated Sewage Disposal

An estimated 15 - 45 kL of sewage from the accommodation camp will be treated at a wastewater treatment plant each day. The treated wastewater will be disposed of via irrigation to a dedicated vegetated area adjacent to the camp, within locally significant floristic community CLP-MWS1. The wastewater will be treated to a minimum low exposure risk level quality and licenced under Part V of the EP Act and the *Health Act 1911*. The Part V EP Act Licence will require the irrigation area to be sized such that nutrient loading does not significantly affect the locally significant vegetation within and surrounding the irrigation area.

Hydrocarbon or Saline Water Spills

Considering the hydrocarbon use described in Section 8.5.6, and the small scale of operations planned for the Proposal, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon contaminated soil that can be remediated via passive means such as bioremediation. Proposed control measures are identified in Section 5.6 and are designed to further reduce the risk of vegetation impacts from hydrocarbon spillage.

Saline water pipelines will run from the borefield to the RO Plant, then from the RO Plant to the evaporation ponds, primarily through locally significant floristic communities CLP-EW1 and CLP-MWS1. A rupture of these pipelines has the potential to release saline water into these floristic communities if it were to occur. Leak detection is proposed for these pipelines, which will trigger an automatic shut-down of the borefield or RO Plant feed. This will restrict the volume of saline water that would be released into the surrounding environment. Audalia will also investigate the option of containing a spill if it were to occur, by placing the pipes in a system of bunds and sumps designed to contain spillage. This option however may not be pursued along the whole length of the pipelines as the area of vegetation likely to be affected by a spill may be less than the clearing required to develop this containment infrastructure. The details of these systems are generally planned and managed via a Works Approvals under Part V of the EP Act (for the RO Plant, evaporation ponds and Process Plant) and a MP under the Mining Act. Additional mitigation measures are proposed in Section 5.6 to minimise the change and potential impact of a saline water pipeline spill.

Weeds

Weeds have the potential to outcompete and displace locally significant native vegetation if introduced or conditions are altered to favour their growth. Weeds may be spread and/or introduced by vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site. Additionally, favourable conditions for weed growth may be encouraged by watering and nutrient loading from the irrigation of treated wastewater.

Nine introduced species were identified during flora/ vegetation surveys (Botanica, 2020c). According to the DPIRD database, none of these taxa are listed as Declared Plants under Section 22 of the BAM Act. Weeds were mostly identified within locally significant floristic community CLP-EW1 which is the most widespread community identified within the DEs (1,237 ha). Vegetation within the locally significant floristic communities range from 'good' to 'very good' with majority of these floristic communities in good condition. No weed infestations were identified within the DEs with only isolated records of weeds observed during flora/ vegetation surveys which were not outcompeting native vegetation (Botanica, 2020d).

Given the presence of nine weed species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with native species (Section 5.6).

Increased Fire Risk

Mining activities have the potential to ignite bushfires through hot work and other activities, however with appropriate firefighting and prevention management measures in place, the development of the Proposal will provide improved access to the region and improved ability to fight fire outbreaks and prevent them from spreading. The potential for increased fire risk is therefore expected to not be significant.

Summary

The Proposal is predicted to result in the disturbance of 544 ha of locally significant vegetation, and potentially affect the health of up to 141 ha of surrounding vegetation from erosion or dust deposition impacts. The combined impact equates to less than 13% of the extent of all locally significant floristic communities, with the exception of HS-MWS1 (53.3%).

Floristic community HS-MWS1 is a relatively small unit, covering an area of only 150 ha within the area mapped by Botanica (2020c; Figure 24). HS-MWS floristic communities were considered significant as they represent Mallee Woodlands and Shrublands vegetation within Hillslope landforms, which aligns with the description of 'Community 1' surveyed by Gibson & Lyons (1998b). It is associated with the 'Bremer Range 491' vegetation association, which covers an area of 67,021 ha.

Floristic community HS-MWS1 was mapped along the north and north-west boundary of the Mine Study Area, which indicates that it extends outside the Mine Study Area (Figure 24). This means that the percentage impact presented in this assessment is conservative.

The disturbance of HS-MWS1 is primarily required for the mine pits and associated access roads, accounting for less than 20% of the predicted extent. 7 ha (<4.7% of the predicted extent) may erode after the closure of the Proposal as it lies within the zone of instability, however only a portion of this area may erode, depending on the structural integrity of the pit slopes. Dust deposition may affect the health of the 7 ha that lies within the zone of instability, as well as an additional 43 ha. Dust deposition may cause some health impacts on this floristic community, primarily during Year 1 of mining, however this is a conservative assessment based on an impact value derived from the lowest impact concentration available in studies for individual flora species.

Strict mitigation measures proposed in Section 5.6 are expected to be sufficient to ensure other potential indirect impacts do not have a significant impact on locally significant vegetation.

Based on the assessment provided in the sections above, the Proposal may result in impacts to a locally significant floristic community (HS-MWS1). Mitigation measures are required to ensure these impacts are minimised such that they are not significant, or offset measures will be required to counterbalance the residual impact.

5.6 MITIGATION

Audalia has mitigated the potential impacts to this factor according to the mitigation hierarchy: avoid, minimise, rehabilitate, offset.

5.6.1 AVOID

Avoidance measures are considered to be critical to the Proposal given the significant ecological values of the area. Audalia conducted extensive flora and vegetation surveys of the areas surrounding the proposed mine and haul road, and have utilised this information to conduct multiple mine planning and haul road design revisions. This avoidance process resulted in the final boundaries of the DEs presented in this ERD, which now avoid the following values identified during the surveys:

1. All current *M. aquilonaris* individuals;
2. All current *M. aquilonaris* areas of occupancy (sub-populations);
3. All *M. aquilonaris* optimal habitat;
4. All catchment areas upslope of current *M. aquilonaris* areas of occupancy (sub-populations);
5. All *Acacia hystrix* subsp. *continua* (P1) records;
6. All *Bossiaea flexuosa* (P3) records;
7. All *Brachyloma stenolobum* (P1) records;
8. All *Eucalyptus pterocarpa* (P3) records;
9. All *Microcybe* sp. Windy Hill (G.F. Craig 6583) (P3) records;
10. Locally significant floristic communities HS-MWS1 and HS-MWS3;
11. More than 96% of *Acacia mutabilis* subsp. *stipulifera* (P3) records within the study areas;
12. More than 79% of *E. rhomboidea* (P4) records within the study areas;

13. More than 40% of *Hakea pendens* (P3) records within the study areas;
14. More than 88% of *Stenanthemum bremerense* (P4) records within the study areas;
15. More than 87% of *Teucrium diabolicum* (P3) records within the study areas; and
16. More than 58% of all locally significant floristic communities.

5.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to terrestrial fauna are minimised:

1. **Implement industry best practice management measures for flora and vegetation:**
    a. Vegetation clearing will be managed through internal ground disturbance procedures;
    b. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operator to minimise clearing;
    c. Progressive clearing will be undertaken;
    d. Raised blade disturbance will be conducted where practicable on tracks to minimise vegetation removal;
    e. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
    f. Water or dust suppressants will be applied to disturbed areas, mine pits and product transfer/storage areas as required to minimise dust generation;
    g. Emergency and fire response capabilities will be maintained to respond to fire outbreaks where possible;
    h. Weed hygiene and management measures / procedures will be implemented to prevent spread of weeds and the introduction of new weed species as a result of construction and operation;
2. **Ensure ground disturbance does not exceed the limits proposed in the Key Proposal Characteristics:**
    a. 1.51 ha of *M. aquilonaris* sub-optimal habitat;
    b. 0.4 ha of *E. rhomboidea* population extent; and
    c. 21 ha of *S. bremerense* population extent;
3. **Obtain and comply with the following approvals:**
    a. Ministerial Statement to be issued under Part IV of the EP Act, which is expected to contain the limits described above;
    b. Works Approval(s) and Licence to be issued under Part V of the EP Act;
    c. MP to be approved under the Mining Act;
4. **Conduct additional significant flora searches of final proposed mine and infrastructure disturbance footprints**. This survey is to be completed during an appropriate season and prior to ground disturbance. It will be used to update the current population and extent of significant flora and to inform the development of the Mine and Infrastructure Plan (discussed below);
5. **Prepare and implement a Mine and Infrastructure Plan**. The Mine and Infrastructure Plan will be developed prior to ground disturbance and will be submitted to DWER to demonstrate that the final locations of mine pits and infrastructure are sited such that:
    a. Disturbance of significant flora and vegetation is minimised as far as practicable; and

   b. The required disturbance of significant flora and vegetation is comparable to the predictions within this ERD;
6. **Implement additional ground disturbance measures for any ground disturbance within *M. aquilonaris* critical habitat, and *E. rhomboidea* or *S. bremerense* population boundaries**:
   a. No areas are to be cleared solely for construction (i.e. all construction ground disturbance is to be within the boundary of the operational footprint);
   b. All areas proposed to be disturbed are to be checked to ensure that they are consistent with the Mine and Infrastructure Plan, and are within the limits proposed in Item 2 above;
   c. A licenced surveyor will mark out the proposed disturbance areas with marker points or tape to ensure that clearing does not occur outside the approved boundaries;
   d. All earthmoving equipment will be cleaned free of any soil material prior to entering this area to minimise the risk of weed introduction;
   e. Seed will be collected from any *M. aquilonaris*, *E. rhomboidea* or *S. bremerense* individuals recorded within the proposed ground disturbance area during the pre-clearance survey;
   f. Any *M. aquilonaris*, *S. bremerense* or juvenile *E. rhomboidea* individuals recorded within the proposed ground disturbance area during the pre-clearance survey will be removed for replanting within potential rehabilitation areas (refer to Section 5.6.4);
   g. After ground disturbance a licenced surveyor will verify that clearing did not occur outside the approved boundaries;
   h. The survey report will be provided to DWER and DBCA;
7. **Implement the Dust Control Management Strategy provided in Appendix 10.** The following key measures are detailed in the Dust Control Management Strategy:
   a. An onsite meteorological station will be installed, in line with the requirements of AS3580.14:2014, to provide reliable real-time wind direction data. The system will allow automatic alerts to be sent to site supervisors to allow immediate responses to changes in wind conditions;
   b. Overburden removal and mining activities within the Vesuvius mine pit will be restricted to times when wind directions are outside the arcs of influence for M. aquilonaris sub-population 1b and 1c (Figure 51);
   c. Water will be applied to suppress dust as required;
   d. Consideration will be given to enclosing the crushing and screening plants;
   e. Cleared areas will be kept to a minimum;
   f. Clearing will be conducted as close as practicable to the commencement of works;
   g. Progressive rehabilitation will be conducted on construction areas not required for operations;
   h. Ensure the TSF surface is kept damp by rotating discharge points;
   i. Apply chemical suppressants or regular water application to access and haul roads;
   j. Visual monitoring will be used in the first instance to determine if additional water dust suppression is required, or whether works should cease until conditions improve;

   k. Dust deposition monitors will be installed at the boundary of *M. aquilonaris* sub-populations and tested on a monthly basis to ensure dust is within the predictions presented in this ERD;

8. **Cease mining activities at the Vesuvius mine pit if dust deposition reaches 4.5 g/m^2 at the boundary of *M. aquilonaris* sub-populations during the key growth period of August to November**. The following activities will be undertaken to ensure compliance with this commitment:
   a. Dust deposition monitors will be installed at the boundary of *M. aquilonaris* sub-populations and tested on a weekly basis during this period;
   b. Continuous dust monitoring units will also be installed to allow a correlation of airborne dust with dust deposition monitoring results in order to allow real-time predictions of dust deposition (which is intended to allow real-time early warning triggers to be implemented);
   c. If the onsite meteorological station records more than 10 mm of rainfall within a 48-hour period then the deposition monitors will be reset to zero (i.e. it is assumed that dust that was deposited on vegetation prior to the rainfall event would have been washed off);
   d. If the onsite meteorological station records wind speeds of more than 30 knots then the deposition monitors will be reset to zero (i.e. it is assumed that dust that was deposited on vegetation prior to the high-wind event would have been blown off);
   e. If mining has ceased at the Vesuvius mine pit due to the dust deposition limit (4.5 g/m^2) being reached at the boundary of *M. aquilonaris* sub-populations then it will only resume if one of the following events has occurred:
      i. The onsite meteorological station records more than 10 mm of rainfall within a 48-hour period;
      ii. The onsite meteorological station records wind speeds of more than 30 knots; or
      iii. The key growth period has ended (i.e. the start of December).
9. **Ensure all surface water crossings are designed to minimise the potential for erosion or sedimentation of downstream vegetation**:
   a. Mine drainage line diversions will be engineered structures designed to convey the full volume of stormwater flows around mine infrastructure, and will be fitted with mechanisms to reduce flow velocity at the drain exits;
   b. Haul Road crossings will be constructed as per the recommendations in GRM (2020c; Appendix 8.3) and by adopting the principles from 'Field guide for erosion and sediment control maintenance practices' (NSW Environment and Heritage, 2012);
   c. Visual monitoring will be conducted after flood events to ensure that there is no ponding or other flow restrictions in the vicinity of the drainage diversions or crossings. The drainage structures are to be revised, reinstalled or redesigned if flow restrictions are noted;
10. **Implement the following measures to minimise the risk and impact of hydrocarbon spills:**
   a. Hydrocarbons will be stored either within a bunded area or within self-bunded tanks;
   b. All spills will be controlled, contained and cleaned up as soon as practicable;

   c. Service vehicles will be fitted with spill kits;
   d. Spill kits will be located at all workshop and fuel storage areas;
   e. Environmental incident recording, investigation and reporting system;

11. **Comply with Water Quality Protection Guidelines and guidance notes**, particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of vehicle maintenance areas and facilities, the siting and operation of wastewater treatment systems, and the handling and storage of other waste materials, including contaminated soils;
12. **Implement additional controls upslope of *M. aquilonaris* critical habitat, or *E. rhomboidea* or *S. bremerense* population boundaries**:
    a. The boundary edge of the mine pit will be excavated first to form an interim sediment sump, which will prevent any hydrocarbon spills or sediment from the remaining works from flowing into the habitat / population areas;
    b. Hydrocarbon storage and servicing of equipment will not occur upslope of the habitat / population areas;
    c. A service vehicle fitted with a spill kit will be present for the duration of any works upslope of these areas to ensure that any spills (if they occur) are cleaned up as quickly as possible and prevented from entering these boundaries;
    d. All earthmoving equipment will be cleaned free of any soil material prior to entering this area to minimise the risk of weed introduction;
    e. The abandonment bund upslope of these habitat / population areas will be permeable (i.e. by using large rocks rather than earthen material), to ensure overland surface water flows to these areas are not impeded;
13. **Prepare and implement a Significant Flora Monitoring Programme**. The programme will monitor the health of significant flora populations within the predicted indirect impact areas presented in this ERD to quantify the scale of impacts to flora health. The monitoring results will be used to:
    a. Assess the effectiveness of mitigation measures; and
    b. Inform any additional mitigation or rehabilitation measures that could be implemented at the Proposal to further reduce the potential indirect impacts to significant flora species;
14. **Conduct an additional *M. aquilonaris* pollinator survey during peak flowing season**. The survey results will be used to:
    a. Improve knowledge of insect pollinators for this species;
    b. Inform the flora species composition to be implemented in rehabilitation to ensure suitable pollinator habitat is reinstated; and
    c. Inform any additional mitigation or rehabilitation measures that could be implemented at the Proposal to further reduce the potential impacts to pollinator species. This could include additional dust controls, or staging of clearing or rehabilitation to avoid works during key pollinator activities.

5.6.3 Rehabilitate

An interim MCP has been prepared to accompany this ERD (Appendix 4) which was developed according to DMIRS Guidelines (2020a and 2020b). The MCP describes the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase including**:**

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks for each of the mine domains; and
- Completion criteria, monitoring and reporting during closure.

The key rehabilitation measures in the MCP that relate to flora and vegetation are summarised below:

1. All infrastructure will be removed from site;
2. Any residual salt within the evaporation ponds will be excavated and either placed in the bottom of the mine pit, in a borrow pit or taken off site;
3. All disturbance areas apart from the mine pit and TSF slopes will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated;
4. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed introduction;
5. Seed will be collected from any *M. aquilonaris*, *E. rhomboidea* or *S. bremerense* individuals recorded within the proposed ground disturbance area during the pre-clearance survey;
6. *E. rhomboidea*, *S. bremerense* and *Hakea pendens* germination trials are to be conducted during the life of the Proposal to target the successful establishment of these species into rehabilitation areas;
7. Other Priority Flora will be included in the rehabilitation seed mix if seed is available and germination is likely to be successful;
8. Flowering plants will be included in seeding to ensure pollinator habitat is adequately reinstated;
9. All depressions will be shaped to prevent the formation of new semi-permanent water sources;
10. All surface water drainage diversions will be rehabilitated to a natural form; and
11. All surface water crossings will be reinstated by removing drainage infrastructure and reshaping as required.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to the construction of the Proposal and will be reviewed and revised every three years.

5.6.4 Offset

After the implementation of the mitigation measures described above and in Section 11, the Proposal is predicted to have a residual impact on the following environmental values:

- *M. aquilonaris* (T);
- *E. rhomboidea* (P4);
- *S. bremerense* (P4);
- The proposed Bremer Range Nature Reserve; and
- The Bremer Range vegetation complexes PEC.

A draft Offset Strategy has been developed (Appendix 12) and will be finalised prior to Proposal implementation. Table 35 describes the measures proposed to offset the residual impacts to these values. Noting the early stage of the assessment process these measures may be revised prior to the commencement of the EPA's assessment of the Proposal as a result of detailed discussions with DBCA and DWER.

Table 35: Proposed flora and vegetation offsets

Offset	Type	Details	Relevant Values
Provision of funding and support (to address any DMIRS concerns) for the development of a conservation reserve or other protected area (i.e. under Section 19 of the Mining Act) for: • *M. aquilonaris* sub-populations 1a, 1d and 1e, and surrounding critical habitat extents • 2 *E. rhomboidea* sub-populations • 12 *S. bremerense* sub-populations The proposed conservation reserve or other protected area is shown in Figure 73	Direct – preservation of existing habitat	The majority of the *M. aqulionaris* critical habitat lies on Audalia's Mining Act tenure and as such Audalia has a suitable understanding of the mineralisation of the proposed area and the economic implications of a protected area. It is Audalia's position that given the current lack of germination knowledge on the species, the *M. aquilonaris* sub-populations should not be disturbed for mining activities and the development of a reserve or other protected area would reduce the likelihood of this occurring in the future. Audalia proposes to provide funding for DBCA to develop an appropriate reserve or other protected area over *M. aquilonaris* sub-populations 1a, 1d and 1e, and surrounding critical habitat extents, including the management of the reserve for a minimum of 20 years. The offset would ensure protection of 76% of known individuals across three of the five current sub-populations. Audalia notes that sub-population 1b and 1c lie on top of mineralised ore therefore these sub-populations have been excluded from the proposed protected area. The exclusion of mineralised ore from the reserve (or other protected area) is expected to provide more assurity that the reserve (or other protected area) would not be opposed by DMIRS or other mining companies. Two *E. rhomboidea* and 12 *S. bremerense* sub-populations also lie within the proposed conservation reserve or other protected area (Figure 73). The offset would ensure protection of only 260 (1.7%) of known local *E. rhomboidea* individuals however will include two of the six local sub-populations (33.3%) and 8 ha of the 12 ha of local population extent (75%). The offset would ensure protection of 29,611 (73.8%) of known local *S. bremerense* individuals and will include 12 of the 25 local sub-populations (48%) and 19.1 ha of the 56 ha of local population extent (34.1%).	*M. aquilonaris, E. rhomboidea, S. bremerense*
Revegetation of previously disturbed vegetation within the *M. aquilonaris* critical habitat boundary (access tracks)	Direct – revegetation of disturbed habitat	There are a number of historic tracks that currently run through the critical habitat boundary. If DBCA deems it suitable, Audalia proposes to cut off the current access to these tracks and rehabilitate the tracks that lie within the critical habitat boundary. Some rehabilitation areas that lie within optimal habitat but outside the sub-populations may be used for germination trials to determine if additional *M. aquilonaris* individuals can become established in these areas. Audalia intends to either fund DBCA to conduct this work or commission experienced consultants to complete the work with direction from DBCA. This work may include provision of suitable access to any conservation reserve created by the above offset.	*M. aquilonaris*

Offset	Type	Details	Relevant Values
On ground management within *M. aquilonaris* critical habitat and local *E. rhomboidea* and *S. bremerense* populations	Direct – management of existing and rehabilitated habitat	Audalia intends to either fund DBCA to conduct on ground management of the *M. aquilonaris* critical habitat and surrounds based on a general provision of funds at a rate to be agreed with DBCA), or commission experienced consultants to complete the work with direction from DBCA. The funding is proposed to be for a minimum of 20 years.	*M. aquilonaris, E. rhomboidea, S. bremerense*
Ongoing *M. aquilonaris*, *E. rhomboidea* and *S. bremerense* research: • Ongoing germination trials • Annual plant counts • Regional searches after fire events • Sub-population health monitoring • Rehabilitation trials • Genetic studies	Indirect – improvement of scientific knowledge of the species	Audalia has commissioned significant research work on these species to inform this ERD. It is proposed to continue the longer-term portions of this research such as germination, changes to plant numbers, health and rehabilitation trials. This information will inform the recovery and preservation planning for these species.	*M. aquilonaris, E. rhomboidea, S. bremerense*
Successful translocation of all impacted *E. rhomboidea* and *S. bremerense* individuals (numbers to be based on pre-clearance survey) to rehabilitation areas	Direct – replacement of existing population	Audalia is currently undertaking germination trials for *E. rhomboidea* and *S. bremerense* to allow the replacement of any individuals that are required to be disturbed for the Proposal. These germination trials will continue to inform the target regrowth and establishment of at least the same number of individuals impacted by the Proposal. Audalia notes that this offset carries some risk as germination success has not yet been confirmed for either species.	*E. rhomboidea, S. bremerense*
On ground management of the Proposed Bremer Range Nature Reserve and Bremer Range Vegetation Complexes PEC	Direct – management of existing habitat and rehabilitation of historic disturbance on closed mining tenements	Audalia intends to either fund DBCA to conduct on-ground management of the Proposed Bremer Range Nature Reserve and Bremer Range Vegetation Complexes PEC or commission experienced consultants to complete the work with direction from DBCA. The funding is proposed to be for a minimum of 20 years and based on a general provision of funds at a rate to be agreed with DBCA.	*M. aquilonaris, E. rhomboidea, S. bremerense,* Proposed Bremer Range Nature Reserve, Bremer Range Vegetation Complexes PEC

An assessment of the adequacy of these offsets is provided in Section 11.

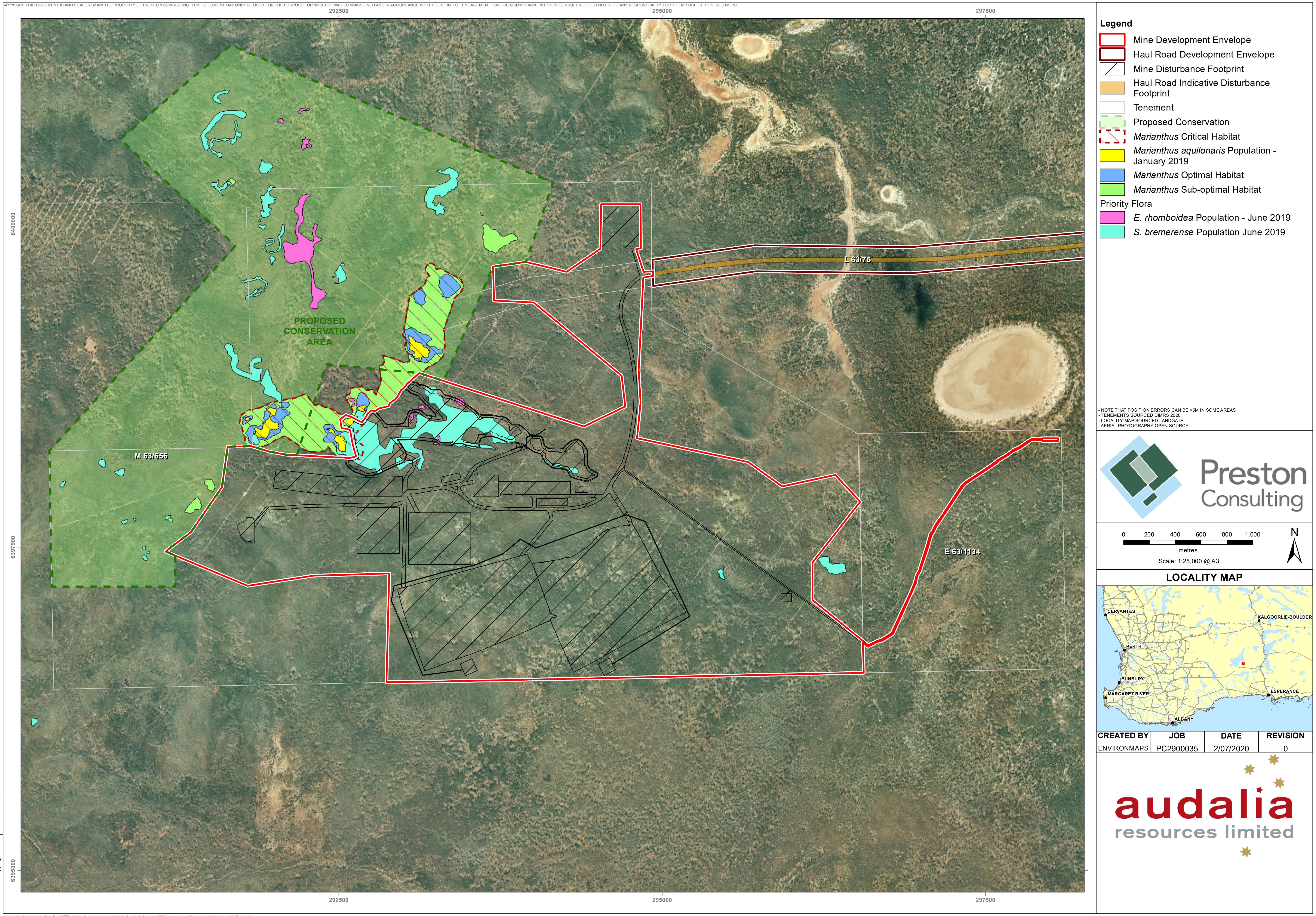


Figure 73: Proposed boundary of conservation reserve or other protected area

5.7 PREDICTED OUTCOME

The EPA's environmental objective for this factor is "to protect flora and vegetation so that biological diversity and ecological integrity are maintained". In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2020a).

Audalia has incorporated extensive avoidance and minimisation measures into the Proposal design. The Proposal that was originally referred to the EPA under Section 38 of the EP Act included the disturbance of *M. aquilonaris*; a Threatened Flora taxon pursuant to the BC Act. Based on the mine plan that was referred, a predicted 24% of known *M. aquilonaris* individuals would have been disturbed.

Audalia has commissioned numerous regional searches for this species and no other populations have been found during these surveys, which has confirmed that the sub-populations at Medcalf are significant for the survival of this species. Given the restricted range and small sub-populations of *M. aquilonaris,* Audalia has substantially altered their mine plan and the Mine DE (Table 36 and Figure 74) to avoid mining within or adjacent to the *M. aquilonaris* sub-populations, and minimising indirect impacts. This has carried significant economic implications, as the highest grade ore resource is located within and adjacent to the sub-populations.

Audalia has also significantly reduced the extent of the Mine DE to exclude Priority Flora populations as much as practicable (Table 36), and will ensure that the final design of the Proposal further reduces the potential impacts to Priority Flora.

Table 36: Comparison of significant flora individuals in the revised Mine DE vs original referral

Species	Regional extent	Individuals in original referral Mine DE	Individuals in revised Mine DE	Reduction from original referral	Reduction of impacts to regional extent
M. aquilonaris (T)	14,627	3,453	0	100%	23.6%
Acacia hystrix subsp. *Continua* (P1)	122	0	0	N/A	N/A
Acacia mutabilis subsp. *stipulifera* (P3)	348,452	1,112	1,107	0.5%	<0.1%
Bossiaea flexuosa (P3)	217	0	0	N/A	N/A
Brachyloma stenolobum (P1)	560	0	0	N/A	N/A
E. pterocarpa (P4)	100	0	0	N/A	N/A
E. rhomboidea (P4)	15,606	1,461	1,198	18%	1.7%
Hakea pendens (P3)	6,783	1,742	1,246	28.5%	7.3%
Microcybe sp. Windy Hill (G.F. Craig 6583) (P3)	26,962	20	20	N/A	N/A
S. bremerense (P4)	40,126	4,856	3,455	28.9%	3.5%
Teucrium diabolicum (P3)	16,153	1,250	1,050	16.0%	1.2%

Despite the measures described above, residual impacts to three significant flora species (*M. aquilonaris, E. bremerense* and *S. bremerense*), the proposed Bremer Range Nature Reserve and the Bremer Range Vegetation Complexes PEC are considered to remain significant once mitigation measures are implemented. Offset measures are proposed to counterbalance these residual impacts to ensure that the EPA objective can be met. These offset measures will be reviewed and refined during the assessment process through discussions with DBCA and EPA Services to ensure they adequately counterbalance the residual impacts.

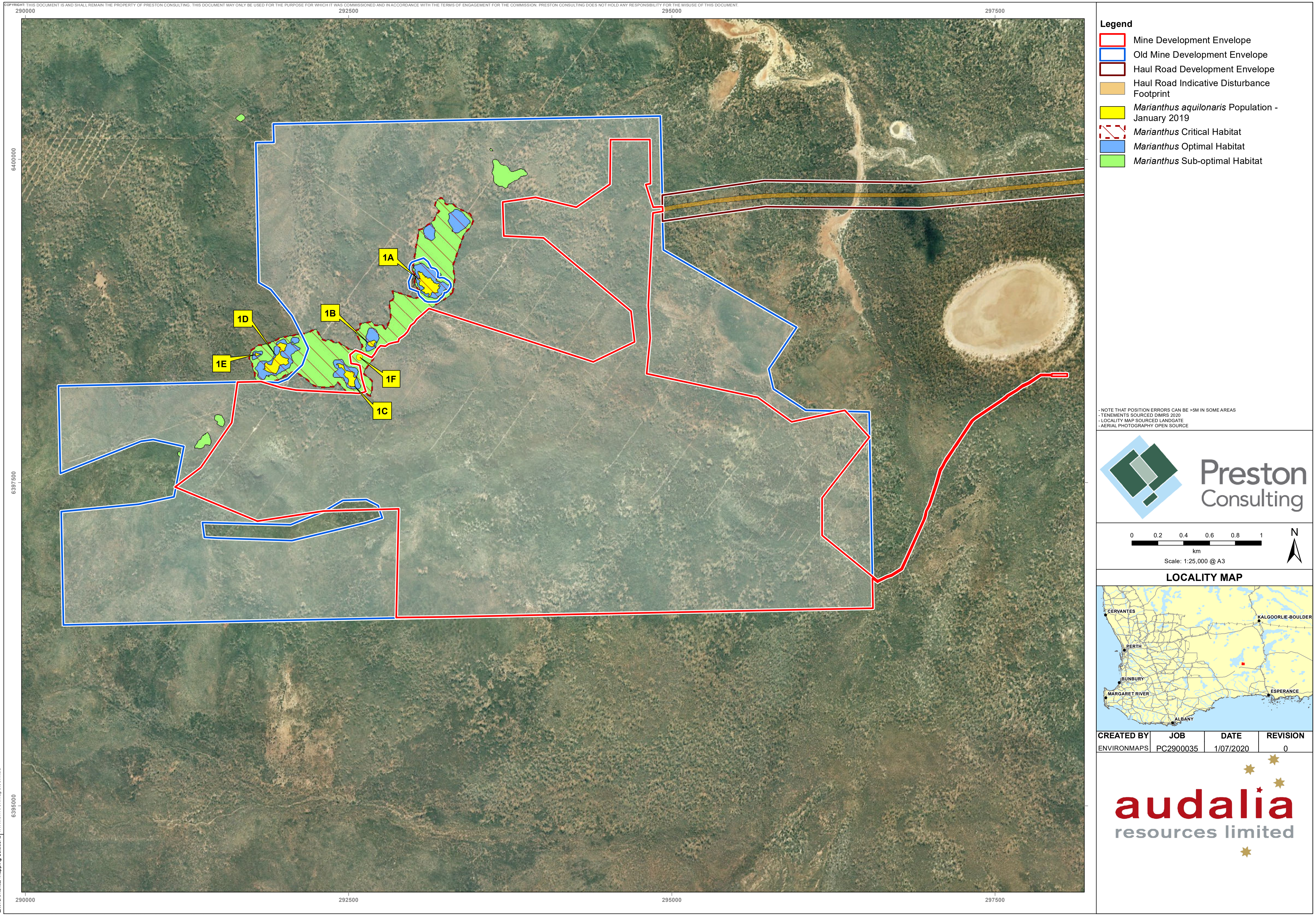


Figure 74: Comparison of M. aquilonaris habitat extent within the revised Mine DE vs original referral

6 TERRESTRIAL FAUNA

6.1 EPA OBJECTIVE

The EPA Objective for this key environmental factor is to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

6.2 POLICY AND GUIDANCE

Relevant EPA guidance documents for terrestrial fauna are listed below:

- Statement of Environmental Principles, Factors and Objectives (EPA, 2020a);
- Environmental Factor Guideline for Terrestrial Fauna (EPA, 2016e);
- Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (EPA, 2016f);
- Technical Guidance: Terrestrial Fauna Surveys (EPA, 2016g);
- Technical Guidance: Sampling of Short Range Endemic Invertebrate Fauna (EPA, 2016h);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA, 2016a); and
- EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2020c).

Other guidance documents for terrestrial fauna are listed below:

- WA Environmental Offsets Guidelines (EPA, 2014);
- Survey Guidelines for Australia's Threatened Birds (Department of the Environment, Water, Heritage and the Arts (DEWHA), 2010);
- Survey Guidelines for Australia's Threatened Mammals (DEWHA, 2011);
- National Recovery Plan for Malleefowl (*Leipoa ocellata)* (Benshemesh, 2007);
- Chuditch (*Dasyurus geoffroii*) National Recovery Plan (DEC, 2012);
- Threat abatement plan for predation by feral cats (Department of the Environment, 2015);
- Threat Abatement Plan for competition and land degradation by rabbits. Commonwealth of Australia (DotEE, 2016); and
- Threat Abatement Plan for Predation by the European Red Fox (DEWHA, 2008).

6.3 RECEIVING ENVIRONMENT

The section below has been sourced from the following reports, provided in Appendix 5:

- Medcalf Vanadium Mining Project Audalia Resources Fauna Survey (Level 2) – Phase 1 and Phase 2 (Harewood, 2020a);
- Medcalf Vanadium Mining Project Proposed Haul Road Fauna Assessment (Harewood, 2020b);
- Insect visitors to *M. aquilonaris* and surrounding flora Nov 2 - 4, 2019 (Prendergast, 2019); and
- Short-range endemic fauna at the Medcalf Project (Bennelongia, 2020a)

6.3.1 Survey Effort

A desktop assessment and field survey have been conducted over the Development Envelopes proposed in this ERD.

Desktop Assessment

A desktop fauna assessment was undertaken, including searches of the DBCA NatureMap Database, the DAWE EPBC Act Protected Matters Search Tool and a review of previous fauna surveys to provide an indication of what fauna species may be present in the study area. Previous fauna surveys from the general area that were used in the desktop assessment include (but were not limited to):

- Forrestania Fauna Survey – Fauna and Fauna Assemblages Report (Biota Environmental Sciences (Biota), 2006a);
- Forrestania Water Disposal Pipeline Survey – Fauna and Fauna Assemblages Report (Biota, 2006b);
- Forrestania Monitoring Survey, Flying Fox Phases III and IV (Biota, 2007a);
- Diggers South Fauna Survey – Phase 1 (Biota, 2007b);
- Spotted Quoll Haul Road Single Phase Fauna Survey (Biota, 2010);
- Biological survey and environmental assessment of the Emily-Ann Project area (Brearley et al., 1998);
- Vertebrate Fauna of the Honman Ridge – Bremer Range district, Great Western Woodlands, WA (Duncan et al., 2006); and
- The biological survey of the eastern goldfields of WA. Part 4. Lake Johnston-Hyden Study Area (How et al., 1988).

Bennelongia was commissioned to perform a desktop assessment compiled by searching WAM and Bennelongia databases. Previous records of terrestrial invertebrates and habitat information were examined to appraise the likelihood of SRE or conservation listed invertebrate species occurring in a 50 km radius from the Proposal centroid. SRE group invertebrates collected as bycatch during previous fauna surveys (Bennelongia, 2020a; Harewood, 2015; Phoenix, 2014) in the area were also considered. This type of desktop search gives only an indication of the level of species richness that can be expected, rather than a precise number of species that exists in the area (Bennelongia, 2020a; Appendix 5.2).

Field Survey – Mine Study Area

The field survey effort for the mine area consisted of a two phase Level 2 terrestrial fauna survey, over a study area (Mine Study Area) of approximately 1,850 ha. The Mine Study Area corresponded to the boundary of M65/656 and is shown in Figure 75. The detailed survey report is provided in Appendix 5.1 (Harewood, 2020a).

The Level 2 terrestrial fauna survey of the Mine Study Area was carried out during two seasonal phases. Phase 1 was undertaken in November 2013 and Phase 2 in March 2014. The field survey included a combination of systematic fauna sampling and targeted / opportunistic searches within the range of habitats present within the Mine Study Area. Nearby locations were also searched for potential presence of significant fauna and Short-Range Endemic (SRE) species and habitats. Specific survey methods included:

- On-site habitat assessment;

- Systematic trapping (consisting of cage traps, Elliot traps, pit fall traps, funnel traps; six sites as shown in Figure 81);
- Use of motion-sensing Infrared cameras, targeting but not limited to Chuditch (*Dasyurus geoffroii*), Malleefowl (*Leipoa ocellata*) and Western Brush Wallaby (*Macropus irma*);
- Avifauna surveys (systematic , traverses, opportunity observations, targeted surveys);
- Acoustic recordings to locate bats (Wildlife Acoustics SM2+ Bat Detector);
- Targeted and opportunistic surveys;
- Nocturnal spotlighting/head torching surveys, including vehicle transects (targeting but not limited to Chuditch and the Western Brush Wallaby); and
- Potential SRE Invertebrate collection and identification.

The Level 2 terrestrial fauna survey included conservation fauna species identified during the desktop review (Harewood, 2020a), as follows:

<u>Chuditch (*Dasyurus geoffroii*) survey effort (Targeted Survey)</u>

A targeted trapping survey for Chuditch (*Dasyurus geoffroii*) was carried out as part of the Level 2 fauna survey of the Mine Study Area. Methods used followed closely the 'standard' techniques documented by DBCA, the main variation being that traps were placed at a higher density along tracks than recommended (i.e. 100 m spacing instead of 200 m) and left open for a longer period (at least six nights as opposed to the recommended four nights) to increase the probability of recording species.

A total of 70 large traps (20 cage traps and 50 large Elliot (B) traps) were placed at approximately 100 m intervals directly adjacent to the two main tracks that run through the Mine Study Area. Traps were checked each morning and rebaited as required.

During the Phase 1 survey, 38 of the traps were left open for eight nights (304 trap nights) with the balance (32 traps) left open for six nights (192 trap nights) giving a total of 496 equivalent trap nights. During the Phase 2 survey, all 70 traps were left open for six nights (420 trap nights), giving a total (over both phases) of 916 equivalent trap nights.

The targeted Chuditch trapping was supplemented by the use of motion-sensing cameras. Twelve motion sensing infrared cameras were located within the Mine Study Area during Phase 1 survey. The cameras were retrieved during the Phase 2 survey. Over 20,000 pictures were taken for the entire survey, though it should be noted that a high percentage of photos at some locations were caused by moving vegetation.

<u>Malleefowl (*Leipoa ocellata*) survey effort (Targeted Survey)</u>

A targeted survey for Malleefowl (<u>*Leipoa ocellata*</u>) was carried out as part of the Level 2 fauna survey of the Mine Study Area, involving a series of closed spaced transects across the main potential impact zones (i.e. open cut pit areas, plant / workshop site, TSF and waste landform) in addition to some adjoining areas. Where practical, transects were spaced about 30 - 40 m apart (actual distance depending on vegetation density / visibility).

The botanical survey team were instructed to record observations of Malleefowl or Malleefowl mound. The aim of the survey was to locate any evidence of the species using the area, primarily by way of locating nest mounds (new and old) although looking for individuals, tracks and feathers was also part of the scope (Figure 78).

Field Survey – Haul Road Study Area

The field survey effort for the haul road consisted of a Level 1 assessment over a study area (Haul Road Study Area) of approximately 17,480 ha. The Haul Road Study Area included the proposed haul road alignment (and associated borrow pits) and a 1 km buffer on either side of the proposed road centreline. The Haul Road Study Area is shown in Figure 76 and the detailed report is included in Appendix 5.3 (Harewood, 2020b).

The Level 1 fauna assessment survey carried out on the Haul Road Study Area was conducted during daytime hours in April 2017. The assessment included a field reconnaissance survey and a literature review carried out to comply with relevant EPA guidance statements to identify fauna of conservation significance (particularly state and Commonwealth-listed threatened, migratory and priority fauna species) present or potentially present within this study area.

As with the Mine Study Area, the botanical survey team were instructed to record observations of Malleefowl or Malleefowl mounds, if observed within the Haul Road Study Area (Figure 78). The aim of the survey was to locate any evidence of the species using the area, primarily by way of locating nest mounds (new and old) although looking for individuals, tracks and feathers was also part of the scope.

Alignment with Technical Guidance

Zoologist Greg Harewood conducted a review of the fauna surveys conducted over the Mine and Haul Road study areas against the methods listed in relevant EPA technical guidance (EPA, 2020a; EPA, 2016e; EPA, 2016f and EPA, 2016g). The survey methods were deemed to align with the technical guidance however there were some unavoidable limitations due to:

- Site condition changes over time;
- Seasonal inactivity during field surveys;
- The potential presence of species within microhabitats that were not surveyed during targeted searches;
- Cryptic species are able to avoid detection; and
- Transient wide-ranging species not present during the survey period.

The habitat requirements and ecology of species known to occur in the wider area are often not well understood or documented. It can therefore be difficult to exclude species from the potential list of occurrence based on a lack of a specific habitat or microhabitat within the survey area. As a consequence of this limitation the potential fauna list produced most likely overestimates the number of species that actually utilise the survey areas. Some species may be present in the general area but may only use the survey area itself on rare occasions or as vagrants (Harewood, 2020a; 2020b).

In recognition of survey limitations, a precautionary approach has been adopted for both surveys. Any vertebrate fauna species that would possibly occur within the survey area (or immediately adjacent), as identified through ecological databases, publications, discussions with local experts/residents and the habitat knowledge of Greg Harewood, has been assumed to potentially occur in the survey area.

The Proposal ESD described the requirement for a Level 2 fauna survey and SRE survey along the haul road. Zoologist Greg Harewood deemed that the fauna assessment carried out was sufficient given that:

- The fauna assessment carried out included a literature review and field reconnaissance survey (Level 1 survey) in addition to targeted searches / surveys for conservation significant species (Level 2 survey). This Level 2 aspect of the assessment included quad bike and on foot transects, installation of camera traps and bat call recordings. Malleefowl (Vulnerable) (one individual, tracks and a very old mound) and the central long-eared bat (Priority 3) (calls) were recorded during these aspects of the survey.
- No restricted habitats or other geographical isolators were identified within the Haul Road DE during the assessment. Habitats within the Haul Road DE are common and widespread in the general area; and
- The narrow, linear disturbance of the proposed haul road would be unlikely to impact a large proportion of any of the broad habitat types identified such that populations of terrestrial fauna and SREs would be significantly impacted.

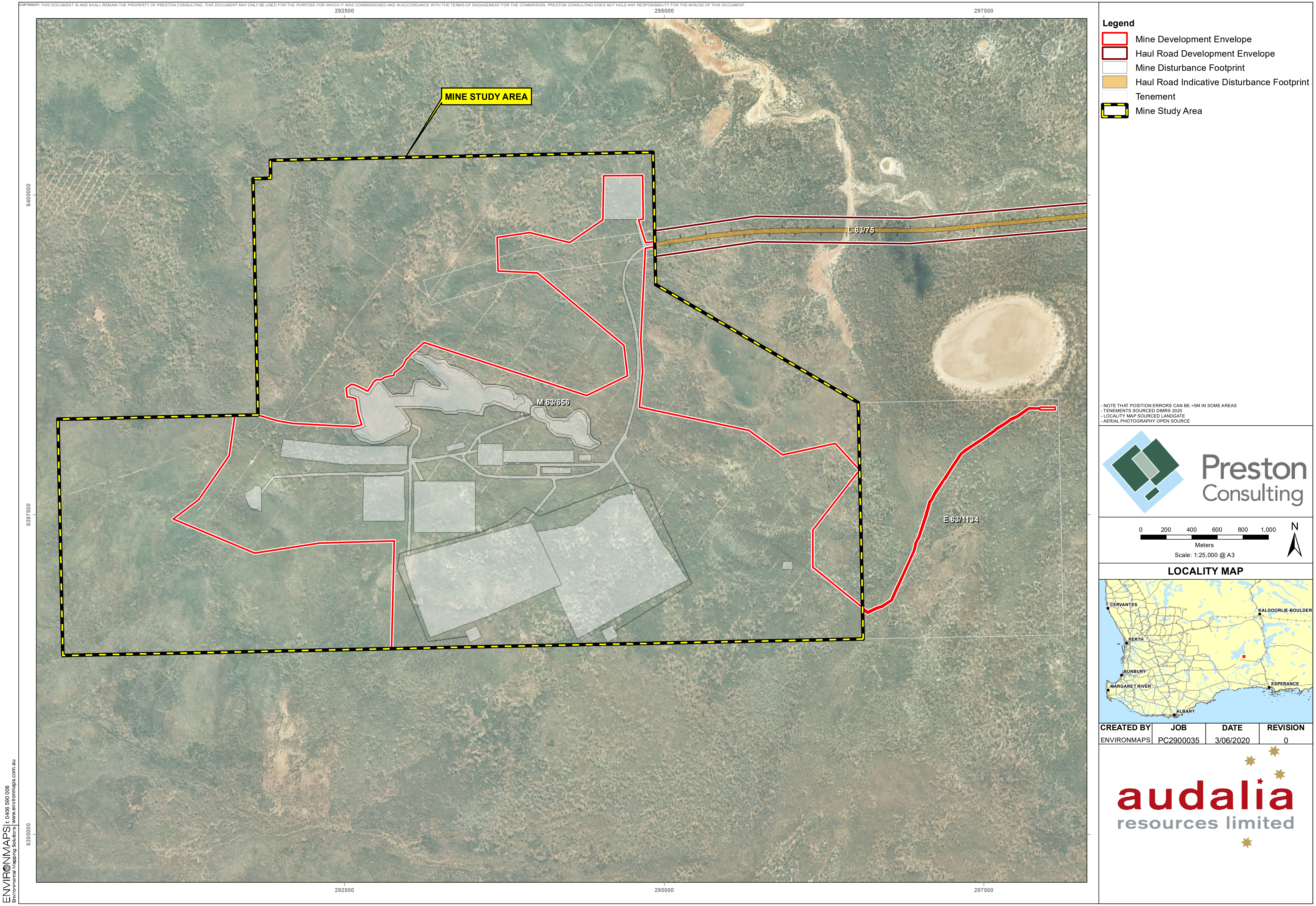


Figure 75: Mine Study Area

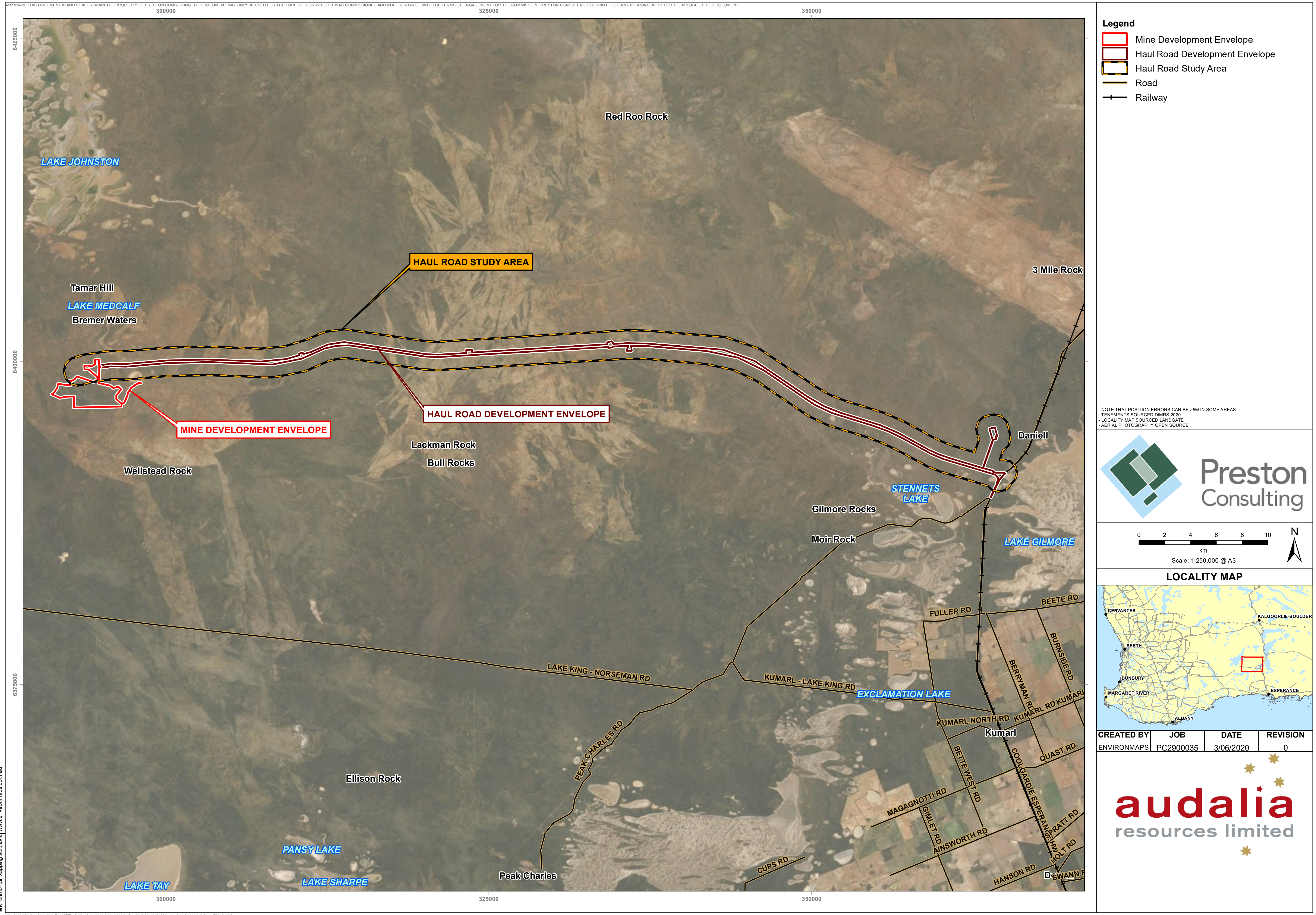


Figure 76: Haul Road Study Area

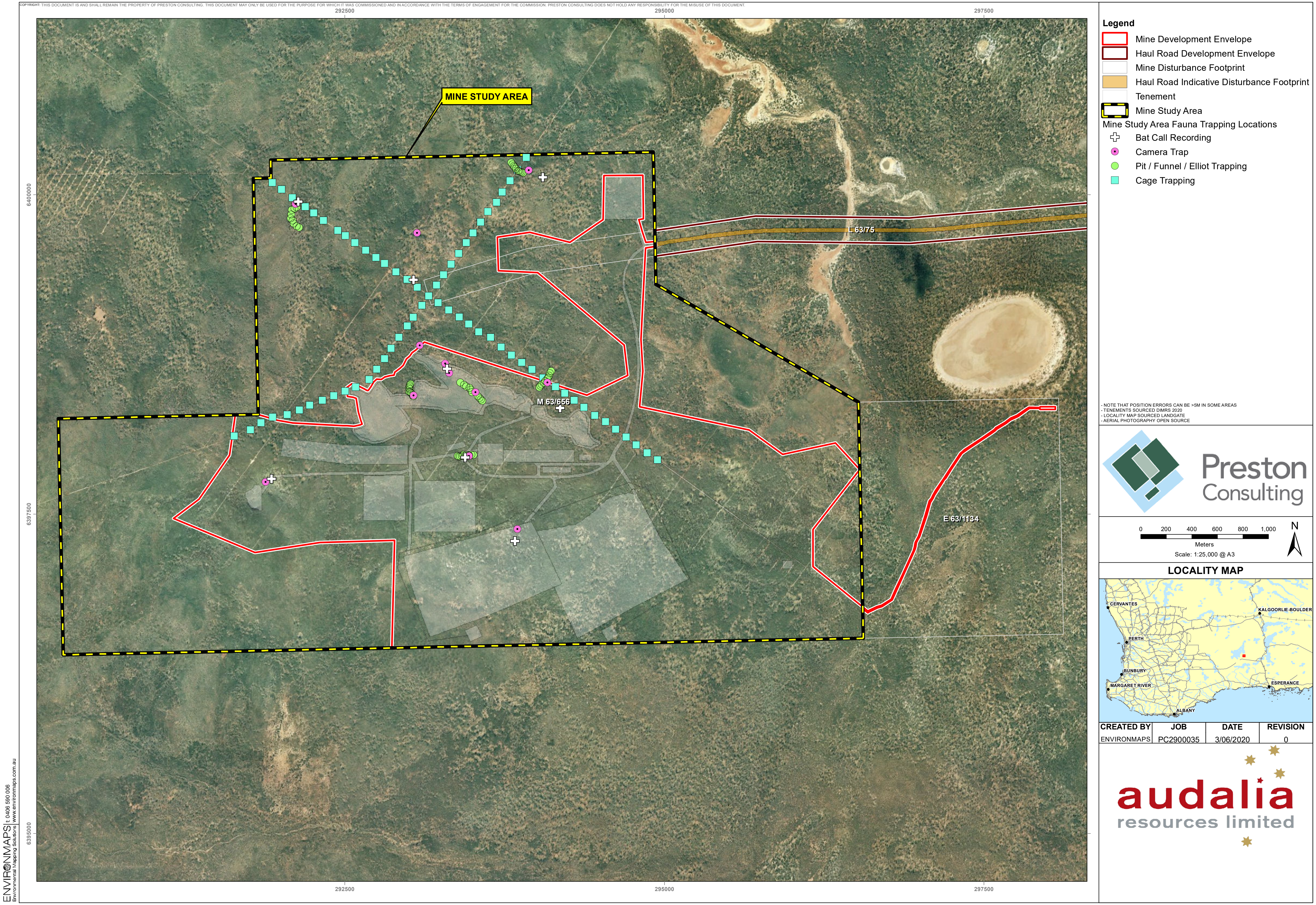


Figure 77: Trapping locations within the Mine Study Area

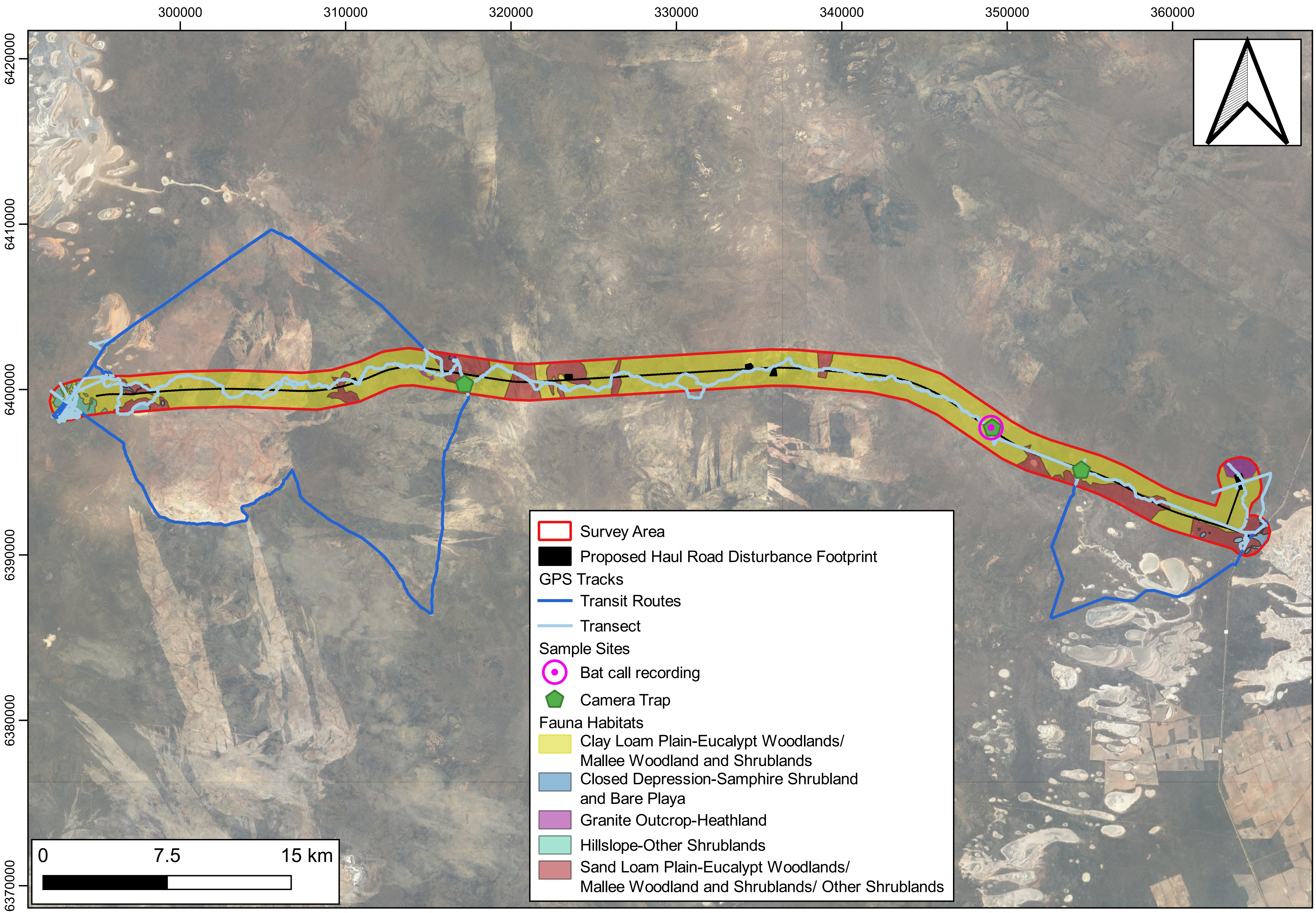


Figure 78: Trapping locations and survey tracks within the Study Areas

Pollinator Assessment

The following section has been sourced from Prendergast (2019).

The Critically Endangered (BC Act) plant species *M. aquilonaris* was thought to rely on native bees for pollination as suggested by its comparatively small flowers and floral features (Prendergast, 2019). In order to inform the EIA for the Proposal an assessment of potential pollinators for *M. aquilonaris* was carried out by Kit Prendergast, a Native Bee Scientist. The assessment was designed to identify insect visitors to *M. aquilonaris* and to determine if they serve as pollinators. At the time of the assessment, *M. aquilonaris* was not in peak bloom however a variety of insect species were collected on and surrounding *M. aquilonaris*.

The current *M. aquilonaris* subpopulations (1a – 1e) were surveyed by Kit Prendergast for their insect visitors. In addition, insects were collected in bee bowls and on surrounding flowering vegetation to further investigate potential pollinator species that may also visit M. aquilonaris. Collection of insect visitors to M. aquilonaris, and bees on surrounding flowering plant species, involved active sampling by Kit Prendergast with an entomological sweepnet. In addition, potential insect visitors were also sampled passively using bee bowls.

On 2 November 2019, all *M. aquilonaris* sub-populations were visited to identify *M. aquilonaris* plants in flower, to target during the surveys the following two days. Sub-population 1e had no plants in flower and so subsequent insect visitor surveys were conducted at *M. aquilonaris* sub-populations 1a - 1d.

Each *M. aquilonaris* subpopulation that had plants blooming was visited for 1 - 2 hrs to undertake insect collections by Kit Prendergast on 3 – 4 November 2019.

During each survey any *M. aquilonaris* plants in flower were observed for half of the time, and flowering plants surrounding the sub-population were surveyed for the remainder. Insects were collected with an entomological sweepnet (the most effective method for sampling native bees (Prendergast et al., 2020) and transferred to vials, labelled with the date, sub-population and plant species and stored in a freezer. All insect taxa visiting *M. aquilonaris* were collected, whereas on plants other than *M. aquilonaris* only bees were collected.

In addition to the active collecting, insects were collected passively using bee bowls (also known as pan traps), which comprised 12 oz. plastic bowls filled with water and a few drops of detergent which acted as a surfactant, lowering the surface tension of the water to prevent insects caught in the bowls from flying out. At each sub-population in the morning one fluoro yellow and one fluoro blue bowl (colours attractive to bees (Prendergast et al., 2020)) were placed near the *M. aquilonaris* plants with the most flowers, and were checked in the afternoon to collect any bees that had been captured in the bowls. The bowls were also left overnight on 3 November 2019 and checked for specimens the following morning to account for the potential to collect nocturnal pollinators or taxa that continued to forage after active surveys had concluded for the day.

Insects were later thawed, pinned, labelled, and identified to the lowest taxonomic level possible by Kit Prendergast using keys, published descriptions, and with reference to the WA Museum entomological collection.

6.3.2 Fauna Habitat

Desktop Review

The desktop review (Harewood, 2020a) stated that specific fauna habitat or microhabitat within the study areas is not well understood and / or documented. It can therefore be difficult to exclude species from the potential list based on a lack of a specific habitat or microhabitat within the study areas.

Mine Study Area

Three fauna habitat types within the Mine Study Area were mapped as part of the botanical survey undertaken (Harewood, 2020a). The fauna habitats are detailed in Table 35. and shown in Figure 79. The majority of vegetation within the Mine Study Area was in a state of regeneration after having been burnt during a series of fires in 2009/2010 (Botanica, 2020c).

Table 37: Fauna habitats in the Mine Study Area

Fauna Habitat	Description	Representative Fauna Habitat Attributes	Conservation Significant Species that possibly occur in habitat
CLP – Clay Loam Plain- Eucalypt Woodland / Mallee Woodland and Shrublands Total Area = 1095 ha (59.1%)	Clay loam plain comprising a mosaic of open Salmon Gum woodland over mixed low shrubs and mallee shrubland over *Melaleuca pauperiflora* and mixed low shrubs.	Range of vegetation strata suitable to a variety of passerine and non-passerine birds. Limited leaf litter due to the presence of smaller / regrowth trees. Relatively dense shrubs providing cover for small fauna. Ground not especially suited to burrowing species.	Malleefowl - *Leipoa ocellata* Peregrine Falcon - *Falco peregrinus* Western Rosella (Inland ssp) – *Platycercus icterotis xanthogenys* Carnaby's Black- Cockatoo - *Calyptorhynchus latirostris* Chuditch - *Dasyurus geoffroii* Western Brush Wallaby - *Notamacropus Irma* Central Long-eared Bat - *Nyctophilus major tor* Lake Cronin Snake - *Paroplocephalus atriceps*
	Example image: 		
HS - Hillslope- Eucalypt Woodland /	Rocky hillslopes (lateritic / limonite) comprising a mosaic of regrowth Eucalypt	Limited exfoliating bark. Limited leaf litter due to the presence of smaller/ regrowth trees.	Peregrine Falcon - *Falco peregrinus* Western Brush Wallaby - *Notamacropus irma*

Fauna Habitat	Description	Representative Fauna Habitat Attributes	Conservation Significant Species that possibly occur in habitat
Mallee Woodland and Shrubland/ Other Shrubland Total Area = 677 ha (36.5%)	woodland / mallee woodland to shrubland over mixed Allocasuarina / Hakea / Melaleuca shrubland and low shrubland/ tussock grassland or sedges.	Limited vegetation strata due to the presence of smaller/ regrowth trees. Limited dense shrubs. Dominated by rocky areas less suitable for burrowing	
	Example image: 		
SLP - Sand Loam Plain Mallee Woodland and Shrubland / Other Shrubland Total Area = 82 ha (4.4%)	Sand-loam plains comprising a mosaic of regrowth sparse mallee shrubland over low open shrubland of Acacia / Grevillea / Melaleuca and open hummock grassland / tussock grassland	Substrate very well suited to a variety of burrowing small mammals and reptiles. Less diverse vegetation strata supporting a less diverse avifauna assemblage.	Peregrine Falcon - *Falco peregrinus*
	Example image: 		

Haul Road Study Area

The Haul Road fauna survey identified five broad fauna habitats within the study area, as detailed in Table 38 (Harewood, 2020b). The broad scale fauna habitats were identified primarily based on landforms; further (often subtle) subdivisions were possible using vegetation structure.

Table 38: Fauna habitats of the haul road study area

Fauna Habitat	Description	Representative Fauna Habitat Attributes	Significant Species that possibly occur in habitat	Survey Effort
CD-Closed Depression- Low samphire shrubland over low open forbland on playa / bare playa Total Area = ~209 ha (~1.2%)	Low samphire shrubland of *Tecticornia indica* over low open forbland of *Disphyma crassifolium* on playa and bare playa.	Halopyte vegetation providing potential food source Limited vegetation strata supporting a lower avifauna assemblage. Limited leaf litter due to absence of trees Substrate very well suited to a variety of burrowing small mammals and reptiles.	None	Traverses within habitat - opportunistic observations / secondary evidence
	Example image: 			
CLP – Clay Loam Plain- Eucalypt Woodland / Mallee Woodland and Shrublands Total Area = ~13,599 ha (~77.8%)	Clay loam plain comprising a mosaic of open Salmon Gum woodland over mixed low shrubs and mallee shrubland over *Melaleuca pauperiflora* and mixed low shrubs.	Range of vegetation strata suitable to a variety of passerine and non-passerine birds. Limited leaf litter due to the presence of smaller / regrowth trees. Relatively dense shrubs providing cover for small fauna. Ground not especially suited to burrowing species.	Malleefowl - *Leipoa ocellata* Peregrine Falcon - *Falco peregrinus* Western Rosella (Inland ssp) – *Platycercus icterotis xanthogenys* Carnaby's Black-Cockatoo - *Calyptorhynchus latirostris* Chuditch - *Dasyurus geoffroii* Western Brush Wallaby - *Notamacropus Irma*	Traverses within habitat - opportunistic observations / secondary evidence. Two camera trap sites along proposed haul road alignment One acoustic bat recorder site along proposed haul road alignment Level 2 fauna study within this habitat previously conducted within the western extremity of the current survey area (as part of the mine study) - included target searches / trapping sites, motion cameras and accoustic bat recorders.

Fauna Habitat	Description	Representative Fauna Habitat Attributes	Significant Species that possibly occur in habitat	Survey Effort
			Central Long-eared Bat - *Nyctophilus major tor* Lake Cronin Snake - *Paroplocephalus atriceps*	
	Example image: 			
Granite Outcrops - Heathland over sparse tussock grassland on granite outcrops Total Area = ~265 ha (~1.5%)	Heathland of *Thryptomene* spp. over sparse tussock grassland of *Neurachne alopecuroidea* on granite outcrop.	Limited vegetation strata supporting a lower avifauna assemblage. Limited leaf litter due to absence of trees Limited dense shrubs. Dominated by granite outcrop limited suitable for burrowing. Provide potential water source for fauna.	Lake Cronin Snake - *Paroplocephalus atriceps*	Traverses within habitat - opportunistic observations / secondary evidence
	Example image: 			

Fauna Habitat	Description	Representative Fauna Habitat Attributes	Significant Species that possibly occur in habitat	Survey Effort
HS - Hillslope-Eucalypt Woodland / Mallee Woodland and Shrubland / Other Shrubland Total Area = ~349 ha (~2.0%)	Rocky hillslopes (lateritic / limonite) comprising a mosaic of regrowth Eucalypt woodland / mallee woodland to shrubland over mixed Allocasuarina / Hakea / Melaleuca shrubland and low shrubland / tussock grassland or sedges. Located within the western extremity of the survey area only within the proposed mine area.	Limited exfoliating bark. Limited leaf litter due to the presence of smaller / regrowth trees. Limited vegetation strata due to the presence of smaller / regrowth trees. Limited dense shrubs.	Peregrine Falcon - *Falco peregrinus* Western Brush Wallaby - *Notamacropus irma*	Traverses within habitat - opportunistic observations / secondary evidence Level 2 fauna study within this habitat previously conducted within the western extremity of the current survey area (as part of the mine study) - included target searches / trapping sites, motion cameras and acoustic bat recorders
	Example image: 			
SLP - Sand Loam Plain Mallee Woodland and Shrubland / Other Shrubland Total Area = ~3,058 ha (~17.5%)	Sand-loam plains comprising a mosaic of *Eucalyptus salicola* woodland over low open shrubland of Acacia / Grevillea/ and open tussock grassland / sedges.	Substrate very well suited to a variety of burrowing small mammals and reptiles. Less diverse vegetation strata supporting a less diverse avifauna assemblage.	Peregrine Falcon - *Falco peregrinus*	Traverses within habitat - opportunistic observations / secondary evidence One camera trap site along proposed haul road alignment

Fauna Habitat	Description	Representative Fauna Habitat Attributes	Significant Species that possibly occur in habitat	Survey Effort
	Example image: 			

Figure 80 provides an overview of the five fauna habitats mentioned in Table 38 and recorded within the Haul Road Study Area. Figure 81 - Figure 83 provide more detailed mapping of these habitats.

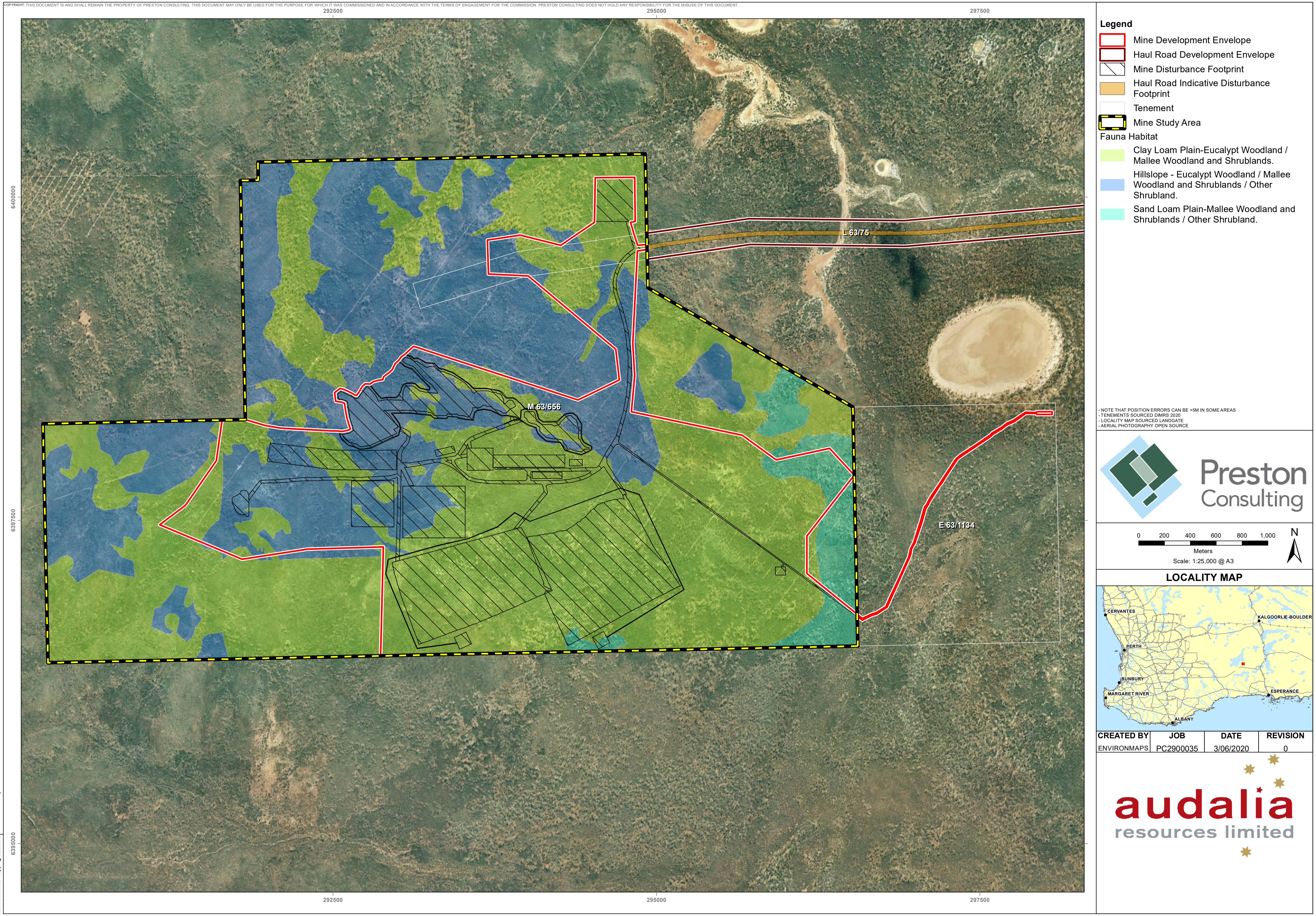


Figure 79: Fauna habitats within the Mine Study Area

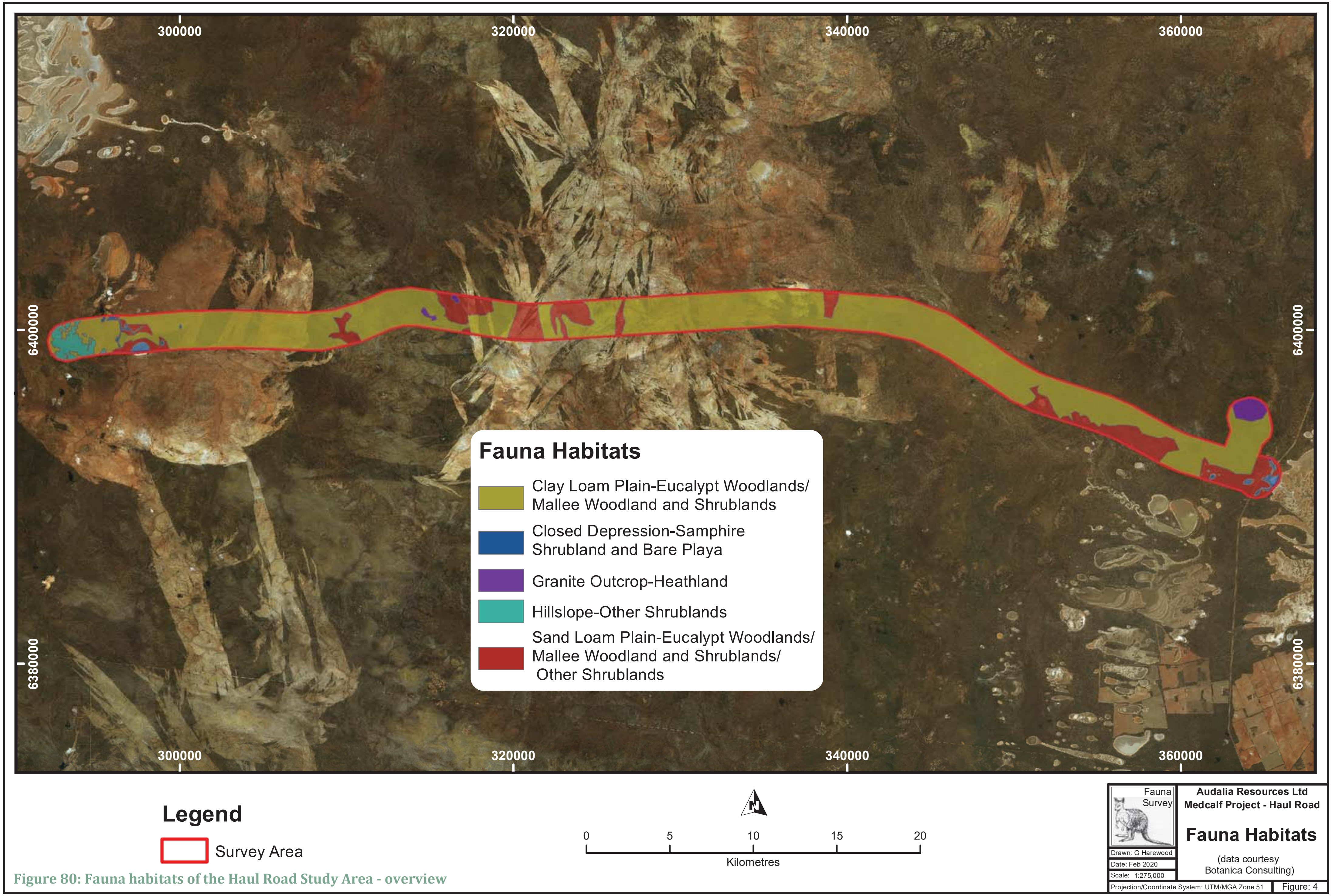
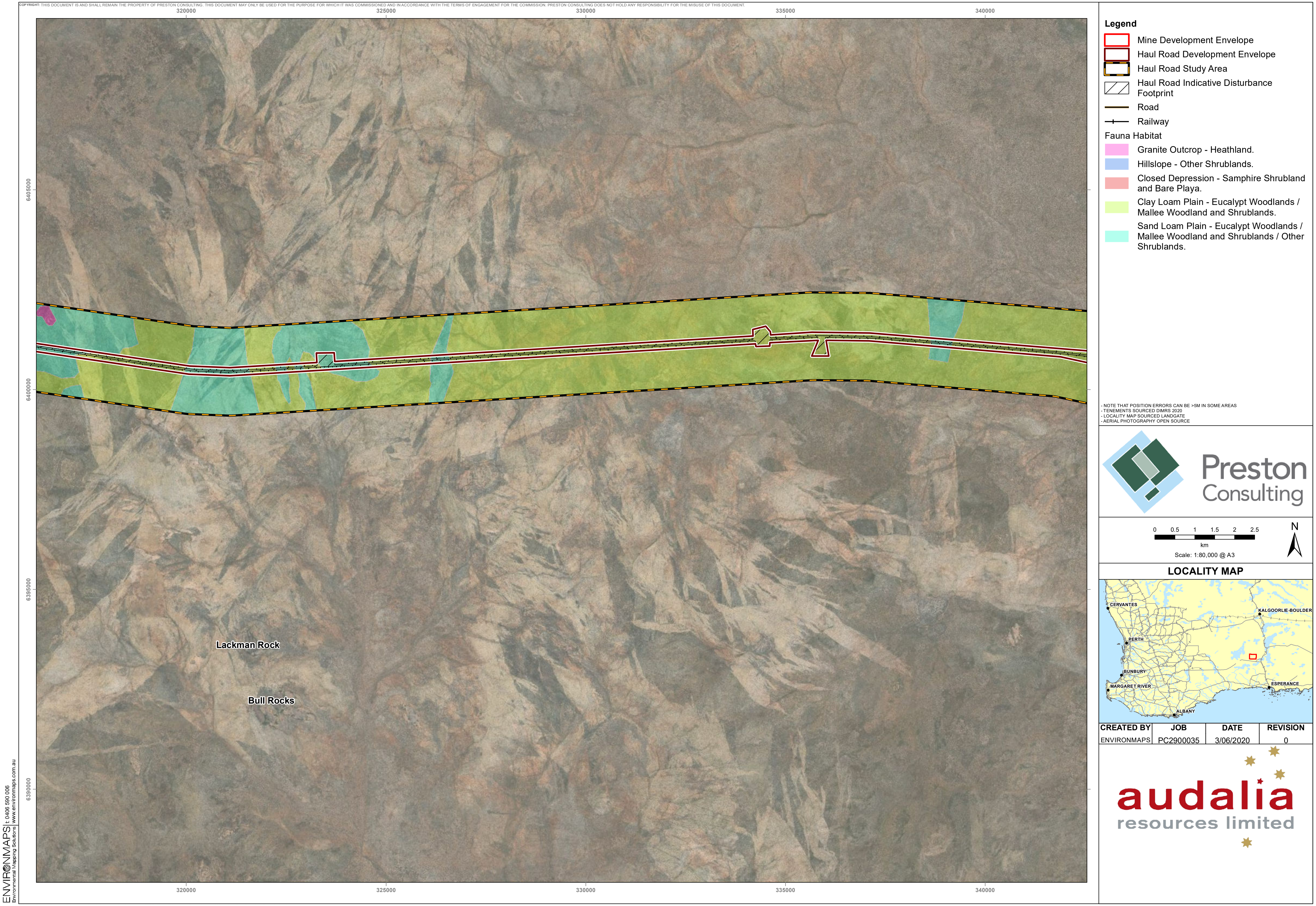


Figure 80: Fauna habitats of the Haul Road Study Area - overview

Figure 81: Fauna habitats of the Haul Road Study Area – detailed (1 of 3)

COPYRIGHT: THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF PRESTON CONSULTING. THIS DOCUMENT MAY ONLY BE USED FOR THE PURPOSE FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION. PRESTON CONSULTING DOES NOT HOLD ANY RESPONSIBILITY FOR THE MISUSE OF THIS DOCUMENT.



CREATED BY	JOB	DATE	REVISION
ENVIRONMAPS	PC2900035	3/06/2020	0

Figure 82: Fauna habitats of the Haul Road Study Area – detailed (2 of 3)

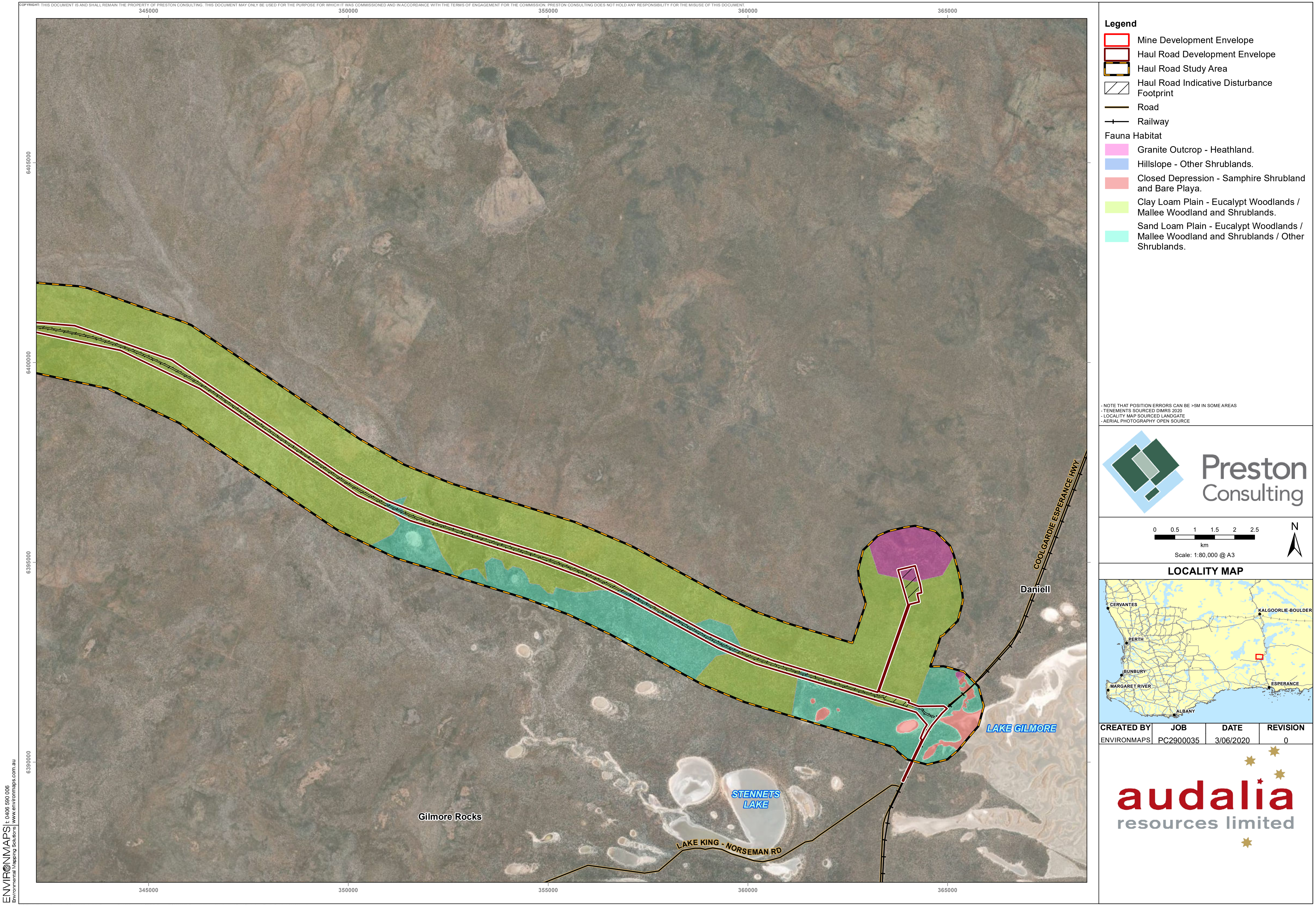


Figure 83: Fauna habitats of the Haul Road Study Area – detailed (3 of 3)

6.3.3 General Fauna

Desktop review

The desktop review identified a total of 230 fauna species likely to occur in the study areas (Harewood, 2020a). These potential fauna included 12 amphibian species, 65 reptile species, 120 bird species and 33 mammal species (including nine bats). From the 230 fauna identified, four were considered specially protected and four priority species (Harewood, 2020a).

Mine Study Area

A total of 124 vertebrate fauna species (including five introduced species) were recorded within the Mine Study Area (Harewood, 2020a), including one amphibian, 32 reptiles, 68 birds and 15 native mammals (including eight bat species). Three of these 124 fauna were considered species of conservation significance.

Haul Road Study Area

A total of 55 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons, calls or photographs) within the Haul Road Study Area during field reconnaissance survey (or on camera traps between April and September 2017). These 55 recorded fauna consisted of one reptile, 40 birds, 14 mammals (including eight bats and four introduced species) (Harewood, 2020b).

Summary

A summary of the number of fauna species identified in the desktop review and surveys undertaken within the Mine Study Area and Haul Road Study Area is shown in Table 39.

Table 39: Summary of potential vertebrate fauna species

Group	Total no. of potential species from desktop assessment	Potential no. of specially protected species	Potential no. of migratory species	Potential no. of priority species	No. of species observed in Mine Study Area	No. of species observed in Haul Road Study Area
Amphibians	12	0	0	0	1	0
Reptiles	65	0	0	1	32	1
Birds	120	3	0	1	68	40
Mammals	24	1	0	1	15	6
Mammals (Bats)	9	0	0	1	8	8
Total	**230**	**4**	**0**	**4**	**124**	**55**

6.3.4 Significant Fauna

Harewood (2020a; 2020b) conducted likelihood assessments based on current available information and the presence or absence of suitable habitat identified during the field surveys. Table 40 identifies the significant fauna that were either recorded during the field surveys or listed by Harewood (2020a; 2020b) as possibly occurring in the study areas. Figure 84 and Figure 85 show the locations of these records.

Table 40: Significant fauna found or that may occur within the study areas

Species	Status	Likelihood of occurrence	Potential habitat
Mammals			
Chuditch (*Dasyurus geoffroii*)	Vulnerable – EPBC Act, BC Act	Possible only in the Mine Study Area, though no evidence of current use of habitat	Marginal habitat present in the Mine Study Area only (CLP).
Western Brush Wallaby (*Notamacropus irma*)	P4 – DBCA Priority	Possible, though no evidence of current use of habitat	Marginal habitat present (CLP, HS).
Central Long-eared Bat (*Nyctophilus major tor*)	P3 – DBCA Priority	Recorded in both study areas. Known to occur	Habitat present (CLP).
Reptiles			
Lake Cronin Snake (*Paroplocephalus atriceps*)	P3 – DBCA Priority	Possible, though no evidence of current use of habitat	Marginal habitat present (CLP, Granite Outcrops).
Birds			
Malleefowl (*Leipoa ocellata*)	Vulnerable – EPBC Act, BC Act	Recorded within the Haul Road Study Area. Possible within the Mine Study Area, though no evidence of current or previous use of habitat.	Marginal habitat present (CLP).
Peregrine Falcon (*Falco peregrinus*)	S7 – BC Act	Possible, though no evidence of current use of habitat.	Marginal habitat present (CLP, HS, SLP).
Western Rosella (Inland ssp.) (*Platycercus icterotis xanthogenys*)	P4 – DBCA Priority	Recorded in the Mine Study Area. Known to occur.	Habitat present (CLP).
Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*)	Endangered – EPBC Act, BC Act	Possible within the Mine Study Area, though no evidence of current use.	Marginal habitat present (CLP).
Fork-tailed Swift (*Apus pacificus*)	Migratory – EPBC Act, BC Act	Possible, flyover only.	Habitat present, however flyover only.

"S" prefix = Schedule, "P" prefix = Priority

The significant fauna listed in Table 40 that potentially utilise the study areas have relatively wide-ranging distributions and there is extensive areas of similar habitat adjacent to the study areas. Further detail on each species is provided in the sections below.

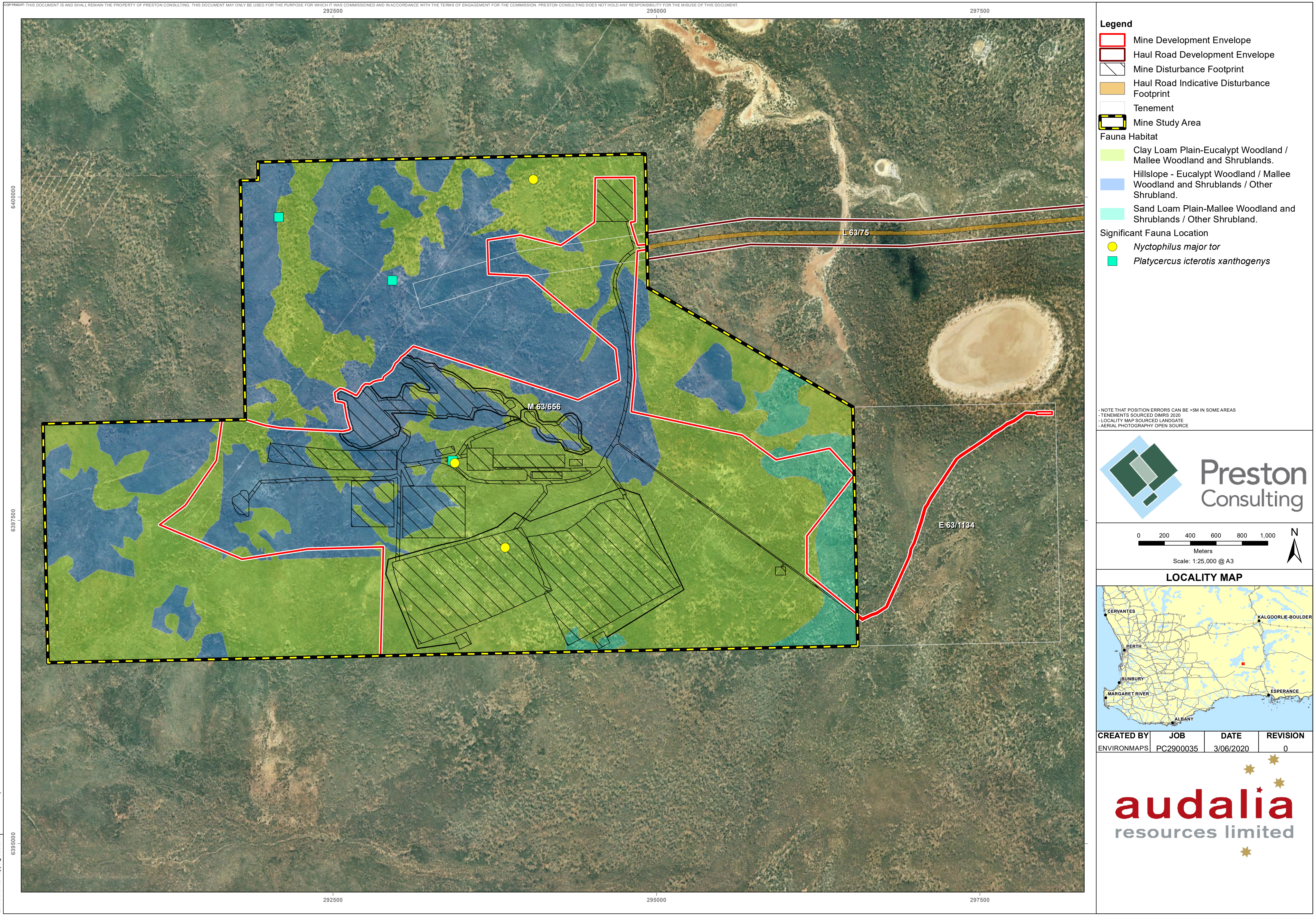


Figure 84: Significant fauna records – Mine Study Area

Figure 85: Significant fauna records – Haul Road Study Area

Chuditch (Dasyurus geoffroii)

The Chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri / Marri / Jarrah forest of southwest WA. It also occurs in very low numbers in the Midwest, Wheatbelt and South Coast Regions, with records from Moora to the north, Yellowdine to the east and south to Hopetoun.

Chuditch are known to have occupied a wide range of habitats from woodlands, dry sclerophyll (leafy) forests, riparian vegetation, beaches and deserts. Riparian vegetation appears to support higher densities of Chuditch, possibly because food supply is better or more reliable and better cover is offered by dense vegetation. Chuditch appear to utilise native vegetation along road sides in the wheatbelt (Department of Conservation and Land Management, 1994). The estimated home range of a male Chuditch is over 15 km^2 whilst that for females is 3 - 4 km^2 (Sorena and Soderquist, 1995).

Potential habitat for this species was identified within the Mine Study Area and as such this species was subjected to targeted surveys. The targeted trapping programme and the deployment of camera traps aimed at determining the presence of the Chuditch however failed to capture / detect any individuals. These results suggest, given the relative small size of the Mine Study Area, the density of traps, number of trap nights over two seasons and over 1,000 camera trap days, that this species is absent from the area or at best present in extremely low numbers. The presence of feral predators (cats and foxes) would also make it difficult for a population to persist in the area though transient individuals may occur on occasions (Harewood, 2020a).

Western Brush Wallaby (Notamacropus irma)

The Western Brush Wallaby is distributed across the south-west of WA from north of Kalbarri to Cape Arid. The species optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some larger areas of mallee and heathland in the wheatbelt (Van Dyck *et al.* 2013).

The study areas are both at the extreme eastern edge of the Western Brush Wallaby's current documented range. It was not recorded during the surveys but may occur, if only occasionally.

Central Long-Eared Bat (Nyctophilus major tor)

The historical distribution of this species included the Coolgardie, Hampton and northern Avon Bioregions in WA, and the Gawler Bioregion and western part of the 'Eyre and York Blocks' Bioregion in South Australia. This species is currently known from several localities in WA and in South Australia. There is no evidence that the species' range has contracted, but it is apparently rare in Great Victoria Desert, Nullarbor and Stony Plains Bioregions, while it is locally common in Coolgardie, Hampton, Gawler and western Eyre-York Block Bioregions (Duncan *et al* (ed) 1999).

The habitat for this species included ground, bark and foliage surfaces, as it forages in and against cluttered airspaces. The species is often netted, and sometimes caught in pit traps, in heavy eucalypt woodlands and tall woodlands of the Coolgardie Bioregion of WA with a tall shrub understorey of *Melaleuca lanceolata, M. pauperiflora, M. quadrifaria, Eremophila spp*. etc. It is less common in open woodlands. It has been netted at dams in the Coolgardie and Hampton Bioregions of WA while in South Australia has been associated with a range of mallee (*Eucalyptus*) species, *Acacia papyrocarpa*, *A. ramulosa, Casuarina cristata* and found to the fringes of the treeless Nullarbor Plain (Duncan *et al* (ed) 1999). It roosts in tree cavities, in foliage and under loose bark (Churchill, 2008).

This species was recorded during the bat survey undertaken within the Haul Road Study Area in April 2017 and during the Level 2 Survey within the Mine Study Area in 2013/2014 (Harewood, 2020a; 2020b).

Lake Cronin Snake (Paroplocephalus atriceps)

This species is known only from a small number of specimens. There are scattered records from Lake Cronin south east to Peak Elenora (Fraser Range) (Cogger, 2014; Bush *et al.* 2007; Wilson and Swan, 2017). Habitat for this species consists of semi-arid woodlands and rocky outcrops (Wilson and Swan, 2017).

This species was not recorded during the field surveys (despite targeted searches) however was considered to possibly occur due to the presence of suitable habitat. This species occurs naturally in low densities and therefore detecting individuals can be difficult even if present. The fact that the Mine Study Area has been repeatedly burnt in recent times may have made the habitat marginal in quality (assuming it was suitable in the first instance) for this species to utilise (Harewood, 2020a).

Malleefowl (Leipoa ocellata)

This species was originally common, but now is generally rare to uncommon, and patchily distributed. Its current distribution is mainly southern arid and semi-arid zones, north to Shark Bay, Jingemarra, Colga Downs and Yeelirrie, east to Earnest Giles Range, Yeo Lake, lower Ponton Creek and to Eucla and west and south to Cockleshell Gully, the Wongan Hills, Stirling Range, Beaufort Inlet, Hatters Hill, Mt Ragged and Point Malcolm (Johnstone and Storr, 1998).

Malleefowl habitat consists of mainly scrubs and thickets of mallee *Eucalyptus* spp., boree *Melaleuca lanceolata* and bowgada *Acacia linophylla*, also dense litter forming shrublands.

A Malleefowl individual was recorded within the Haul Road Study Area, along with some recent tracks that were located outside this study area, and an extinct, very old nest mound (Figure 85; Harewood, 2020b; Appendix 5.3). No other records were noted despite ecological field personnel being tasked with recording any sightings. Figure 86 shows the GPS tracks of ecological surveys conducted within the Study Areas.

Peregrine Falcon (Falco peregrinus)

Individuals of this species are uncommon / rare but wide-ranging across Australia. It is moderately common at higher levels of the Stirling Range, uncommon in hilly, north-west Kimberley, Hamersley and Darling Ranges; and rare or scarce elsewhere (Johnstone and Storr 1998).

It has a diverse habitat, ranging from rainforest to arid shrublands, from coastal heath to alpine (Morcombe, 2004), and occurs mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr, 1998). The species utilises the ledges, cliff faces and large hollows / broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey and is known to utilise decommissioned open cut pit walls for nesting.

This species potentially utilises some sections of the study areas as part of a much larger home range, though records in this area are rare. No potential nest sites were observed in any trees.

Western Rosella (Inland ssp.) (Platycercus icterotis xanthogenys)

The Inland Western Rosella was formally known from the Wongan Hills region in the central wheatbelt and from places including; Kununoppin, Moorine Rock, Parker Range, Yardina Rock and Ten Mile Rocks, west to Toodyay, the Dale River, Mt Saddleback and Kojonup, south to the Stirling Range, the lower Fitzgerald River, Ravensthorpe, Frank Hann National Park and Red Lake (Harewood, 2020a). As it is evident in the number of regions the species is found, it is mobile and occupies a large home range (Harewood, 2020a).

This species occupies a diverse range of habitats including tall wet karri to dry woodland and mallee inland towards the Nullarbor. It is common in salmon gum and wandoo woodland, and farmland with scattered trees. It is usually in pairs or only small parties (rather than in a flock). It is often found where water is available and in cleared areas (Morcombe & Stewart, 2011). Specifically, this species mainly inhabits eucalypt and casuarina woodlands and scrubs, especially of wandoo, flooded gum, salmon gum, tall mallees and *Allocasuarina huegeliana*. Specific seeding trees such as *E. wandoo, A. huegeliana* and shrubs or herbs such as *Glischrocaryon flavescens* and *Olearia revoluta* and flowering *Melaleuca acuminata* and *Eucalyptus eremophila* are utilised (Harewood, 2020b).

The species feeds quietly in foliage or on the ground. From August - January it nests in a hollow tree branch or trunk.

Local extinctions of this species have occurred across 40% of the species total range. The species is on the continued decline in the wheatbelt but is considered stable in the western woodland and forest (Harewood, 2020a).

This species was observed within the Mine Study Area on five occasions in small groups (2 - 7 individuals) at trap site 1 and 3 (Figure 84) and in similar woodland / forest vegetation in the north-western section of this study area (Harewood, 2020a). It was not recorded within the Haul Road Study Area and is considered less likely to occur in the east (Harewood, 2020b).

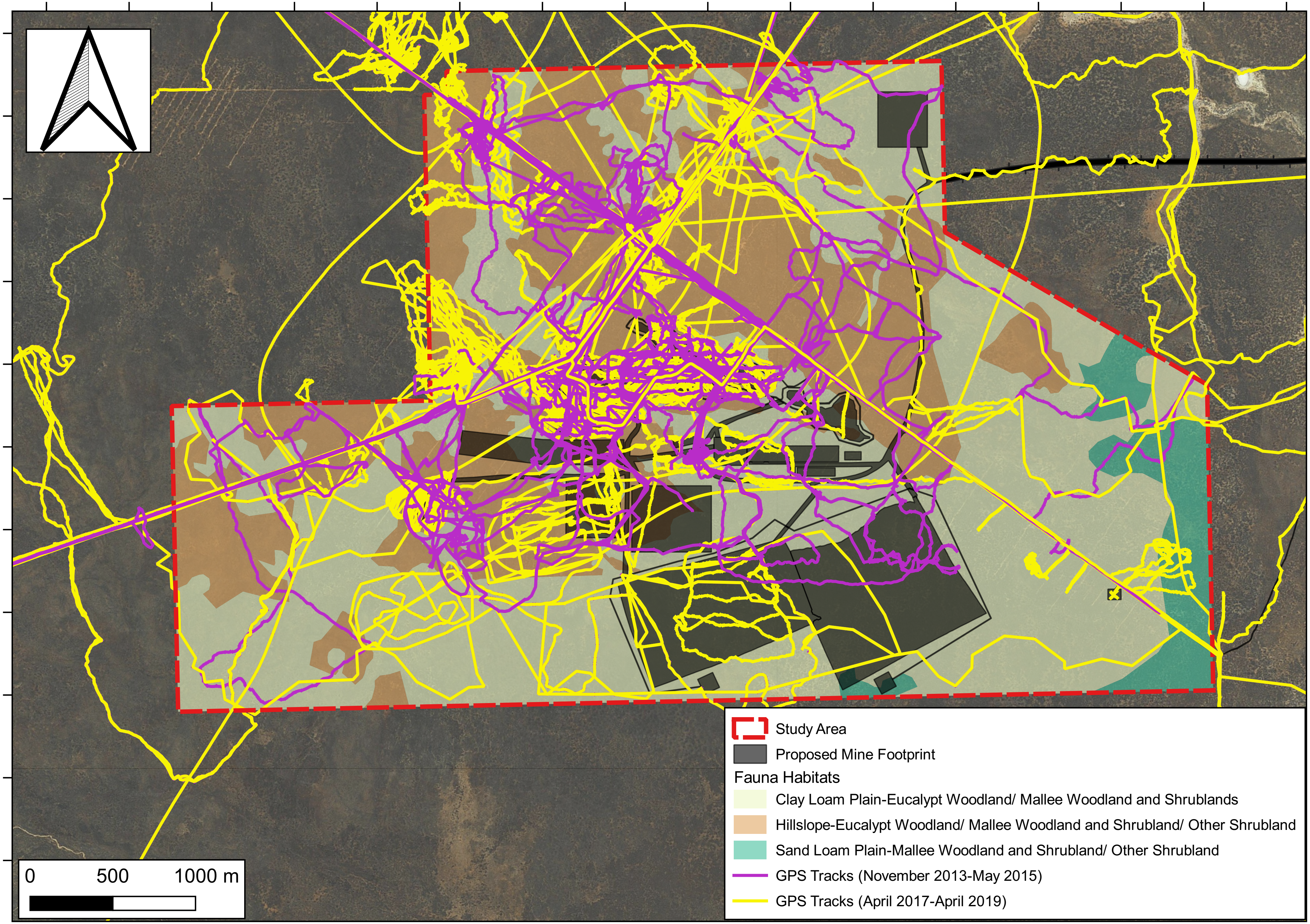


Figure 86: GPS tracks of ecological surveys

Carnaby's Black-Cockatoo (Calyptorhynchus latirostris)

Carnaby's Black-Cockatoo is endemic to, and widespread in, the south-west of WA. It occurs from the wheatbelt, in areas that receive between 300 - 750 mm of rainfall annually, across to wetter regions in the extreme south-west, including the Swan Coastal Plain and the southern coast. Its range extends from Cape Arid in the south-east to Kalbarri in the north, and inland to Hatter Hill, Gibb Rock, Narembeen, Noongar, Wongan Hills, Nugadong, near Perenjori, Wilroy and Nabawa. Most records are from south of 29°S and west of 120°E (Barrett et al., 2003; Saunders, 1974a, 1979; Saunders & Ingram, 1995; Saunders et al., 1985; Storr, 1987, 1991; Storr & Johnstone, 1988). The species has also been recorded north to the lower Murchison River and east to Wadi Forest, Nugadong, Manmanning, Durokoppin, Lake Cronin, the Ravensthorpe Range and head of the Oldfield River, and 20 km east-south-east of Condingup.

This species occurs in uncleared or remnant native eucalypt woodlands, especially those that contain salmon gum and wandoo, and in shrubland or kwongan heathland dominated by hakea, dryandra, banksia and grevillea species (Saunders 1974b, 1979, 1980, 1982, 1986). It also forages in forests containing marri, jarrah or karri (Nichols & Nichols 1984; Saunders 1980).

The Haul Road Study Area is outside the current documented range of this species and the Mine Study Area lies at the extreme north-eastern edge of the current documented range. It may occur occasionally but the diminished quality of the woodland / forest habitat as a consequence of recent fires may make the area unsuitable or at best very marginal.

Fork-tailed Swift (Apus pacificus)

The Fork-tailed Swift is a summer migrant (October - April) to Australia. Its habitat is low to very high airspace over varied habitat from rainforest to semi-desert (Morcombe, 2004).

It is potentially a very infrequent summer visitor to the study areas but is entirely aerial and largely independent of terrestrial habitats. If present it would only occur very occasionally if at all, and then only temporarily (Harewood, 2020b).

6.3.5 *M. aquilonaris* Pollinator Assessment

In a separate study, Prendergast (2019) surveyed insect visitors to *M. aquilonaris* and surrounding vegetation in the mine study area. A total of 47 species of native bees were collected with only six species (including undescribed species) collected in the vicinity of *M. aquilonaris*.

The vast majority of individuals and species were collected on *Eucalyptus livida*, which hosted a prolific number of native bees as well as other insects.

Table 41: Insect visitors collected on *M. aquilonaris* flowers

Species	Total no. recorded visiting *M. aquilonaris*	Sex	Number of individuals	*M. aquilonaris* sub-population	Date of collection
Bees					
Lasioglossum (Chilalictus) florale	2	M	1	d	3/11/2019
		F	1	d	3/11/2019
Xanthesma sp	1	M	1	a	4/11/2019
Lasioglossum (Chilalictus) castor	1	F	1	a	4/11/2019
Megachile 66 "shelf clypeus"	1	F	1	a	4/11/2019
Megachile maculosipes	1	M	1	a	4/11/2019
Megachile 65 "prongs"	1	F	1	c	4/11/2019
Flies					
Syrphidae Sp.1	1			a	4/11/2019
Bombyliidae Geron sp.1	2			a	4/11/2019

The two halictids collected - *Lasioglossum (Chilalictus) florale* and *Lasioglossum (Chilalictus) castor* - are both described, and there is existing published information on their biology. Both species have a wide range; *L. castor* occurs throughout south-west WA, and the geographic range of *Lasioglossum (Chilalictus) florale* encompasses most of mid-west, south-west and southern Australia, and it is known to be locally abundant in some locations (Walker, 1995).

The sole euryglossine bee that was collected on *M. aquilonaris* was an undescribed *Xanthesma* species; consequently whilst this species specific range and habitat requirements are unknown, this genus is known to nest in soil (Houston, 1969).

Three of the native bee species collected foraging on *M. aquilonaris* are undescribed, and potentially even new to science, and as such their range and potential conservation status is entirely unknown. A similar situation exists for *Megachile maculosipes* as it is not officially recognised, having been named and published in a thesis (King, 1986).

In addition, three flies (Diptera) were observed visiting *M. aquilonaris*: two tiny flies (*Geron* sp., *Bombyliidae*) were collected on the flowers in the afternoon at sub-population a, and a hoverfly (*Syrphidae*) at sub-population 1d (Figure 35). Whether these fly taxa serve as pollinators is unknown, as although flies can potentially be pollinators (Inouye, Larson, Ssymank, & Kevan, 2015), they can also be nectar thieves and are generally less effective at pollinating than bees (Willmer, Cunnold, & Ballantyne, 2017).

The numbers of bees collected in bee bowls next to *M. aquilonaris* far exceeded the number that was recorded actually foraging on the plants. This highlights a pitfall of bee bowls in that they cannot demonstrate that bees are actually foraging on the plants (Prendergast et al., 2020).

The relative paucity of insect visitors to *M. aquilonaris* observed during these surveys cannot be taken as conclusive evidence that few insects visit this species. Due to Prendergast visiting well after peak flowering, the few scattered flowers did not represent an attractive foraging resource for bees, which are known to target larger, clumped patches of flowers (Cresswell & Osborne, 2004; Sih & Baltus, 1987).

The native bee taxa were small to medium-sized, and therefore have limited flight ranges (Zurbuchen et al., 2010). As bees are central-place foragers, their foraging and nesting resources must be within flight range (Michener, 2007). With genetic data on *M. aquilonaris* suggesting limited pollen exchange between the sub-populations, it appears that the sub-populations are isolated from the perspective of these pollen vectors (Prendergast, 2019).

6.3.6 Short-range Endemic Fauna

Desktop Review

A total of 342 individuals from at least 34 species belonging to SRE groups have been previously recorded in the search area (Bennelongia (2020a; Figure 87), including 12 species of spider, two species of pseudoscorpion, two species of scorpion, six species of centipede, four species of millipede, two species of tiger beetle, three species of slater, and three species of land snail. 31 records are identified to higher order only due to being the wrong sex (females) or life stage (juveniles) for species identification. 16 of these might belong to other species already recorded (not viewed as unique species, such as Aname sp., for example), whereas the other 15 must represent unique species, as no other species from the same family / genus were recorded in the search area (such as the isopod *Philosciidae* sp., for example).

The desktop review revealed that 34 species of SRE may be present in the survey area, and three listed invertebrates (the butterflies *Ogyris subterrestris petrina* and *Jalmenus aridus*; and the trapdoor spider *Idiosoma intermedium*) could also occur in the vicinity of the Proposal, although they have never been recorded in the search area. The SREs that may be present within the survey area are detailed in Table 42.

Table 42: SRE's that may be present within the survey area

Higher Classification	Lowest Identification
Araneae	
Anamidae	Aname `MYG398`
	Aname `MYG399`
	Aname sp.
	Proshermacha sp.
	Teyl `MYG510`
	Kwonkan currycomboides
	Anamidae sp.
Barychelidae	*Idiommata* sp.
	Synothele houstoni
Euagridae	*Cethegus* sp.
Halonoproctidae	*Conothele* sp.
Idiopidae	*Blakistonia olea*
	Blakistonia sp.
	Idiosoma `charlesi`

Higher Classification	Lowest Identification
	Idiosoma sp.
	Arbanitinae sp.
Unknown family	Mygalomorphae sp.
Lycosidae	Lycosidae sp.
Pseudoscorpiones	
Garypidae	*Synsphyronus* `8/3 McDermid Rock`
Garypinidae	*Amblyolpium* `WA1`
	Pseudoscorpiones sp.
Scorpiones	
Buthidae	*Isometroides* `goldfields 1`
	Isometroides sp.
Urodacidae	*Urodacus* `*armatus* complex`
	Urodacus sp.
Geophilida	
Chilenophilidae	Chilenophilidae sp.
Geophilidae	Geophilidae sp.
Unknown family	Geophilida sp.
Scolopendrida	
Scolopendridae	*Cormocephalus* sp.
	Scolopendridae sp.
Scutigerida	
Scutigeridae	*Pilbarascutigera* cf. *incola*
	cf. *Prothereura* sp.
Lithobiomorpha	
Henicopidae	*Lamyctes* 'nr *africanus'*
Unknown family	Lithobiomorpha sp.
Polydesmida	
Paradoxosomatidae	*Antichiropus* `*saeda*`
	Antichiropus cincinnus
	Antichiropus paracalothamnus
	Antichiropus sp.
Unknown order	Diplopoda sp.
Spirostreptida	
Iulomorphidae	*Atelomastix* sp.
Coleoptera	
Carabidae	*Cicindela avita*
	Cicindela vannideki
Isopoda	

Higher Classification	Lowest Identification
Armadillidae	*Buddelundia* sp.
	Pseudodiploexochus sp.
Philosciidae	Philosciidae sp.
Stylommatophora	
Bothriembryontidae	*Bothriembryon* cf. *sedgwicki*
	Bothriembryon sp.
cf. Hygromiidae	cf. Hygromiidae sp.
Punctidae	*Westralaoma* sp.
	Punctidae sp.

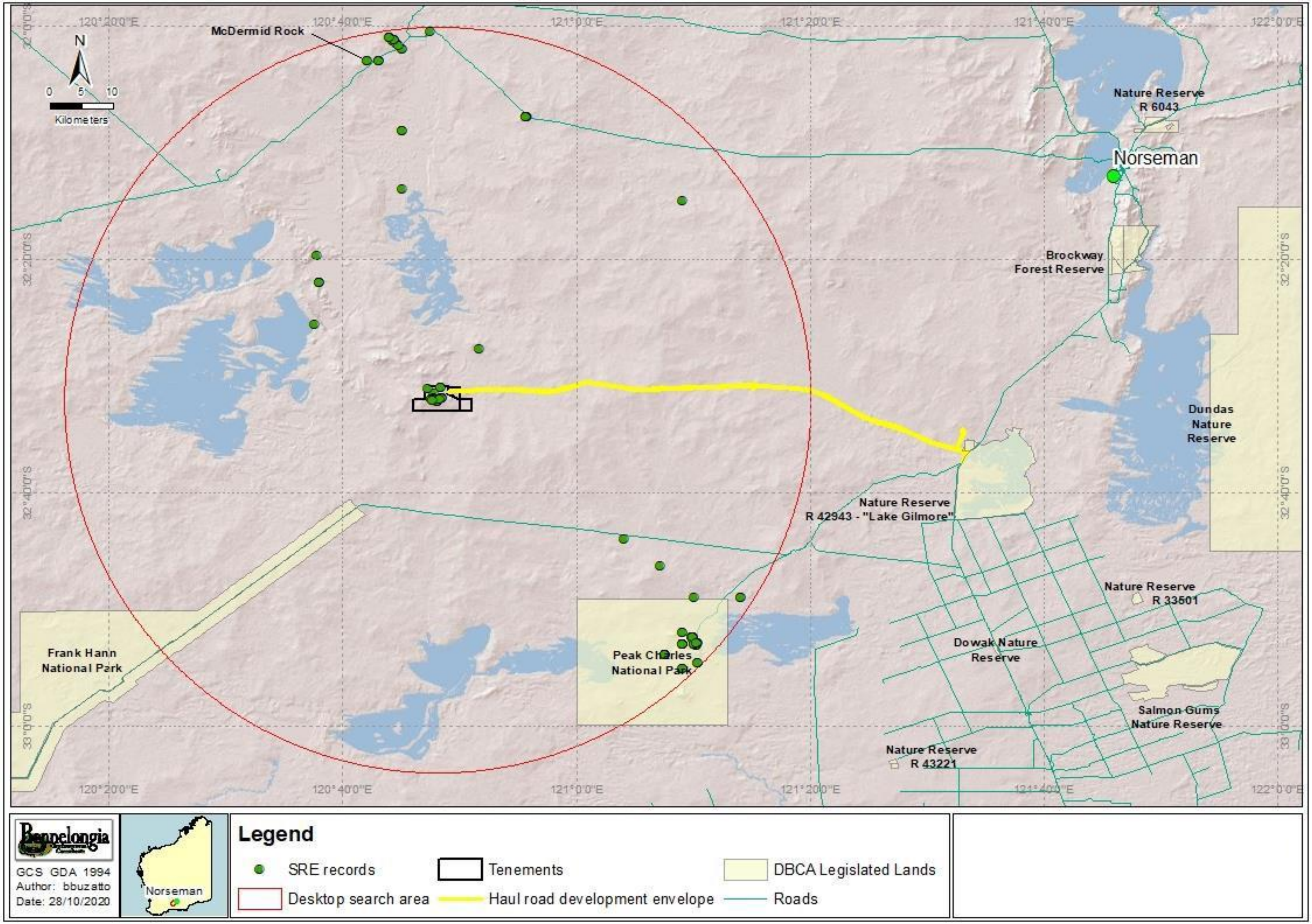


Figure 87: Locations of regional SRE records

Field Survey

Completed SRE field work is detailed below. Bennelongia is currently undertaking an additional detailed SRE field survey over the DEs and the results of this survey will be provided with the response to public submissions.

A total of 25 invertebrate species were collected during the Level 2 fauna survey of the Mine Study Area. No invertebrate species were confirmed as being SRE fauna, however five were classified as potential SREs because some members of the same genus are known as SREs (Harewood, 2020a). Without additional information, particularly on regional distributions, their actual SRE status is impossible to determine. The potential SREs are detailed in Table 43 and the location of the records are shown in Figure 88.

Table 43: Potential SRE invertebrates

Higher Taxon	Species	Recorded in fauna habitat type
Mygalomorphae (trapdoor spiders)		
Nemesiide	*Aname* 'WYG398'	Hillslopes – Eucalypt woodlands or Mallee woodlands over shrublands or other shrublands Clay-Loam Plains – Eucalypt woodlands or Mallee woodlands over shrublands
	Aname 'WYG399'	Hillslopes – Eucalypt woodlands or Mallee woodlands over shrublands or other shrublands
	Aname sp. Indet.	Hillslopes – Eucalypt woodlands or Mallee woodlands over shrublands or other shrublands
Scorpiones (scorpions)		
Buthidae	*Urodacus armatus*-group	Clay-Loam Plains – Eucalypt woodlands or Mallee woodlands over shrublands
Isopod (slaters)		
Armadillidae	*Buddelundia* '85'	Clay-Loam Plains – Eucalypt woodlands or Mallee woodlands over shrublands

Mygalomorphae (trapdoor spider) – Aname

Members of the mygalomorph spider family Nemesiidae are represented in WA by several genera, including *Aname, Chenistonia, Yilgarnia, Stanwellia, Teyl, Swolnpes* and *Kwonkan* (Main & Framenau, 2009). They usually dig burrows in the soil, and do not cover their burrow entrances with lids.

The genus *Aname* currently includes 37 named species in Australia and is well represented by four named and numerous unnamed species from many different regions in WA. *Aname* currently represent a highly diverse array of species of very small to large spiders. Many *Aname* species appear to have restricted distributions as shown by two studies from northern Australia, including the Pilbara (Harvey et al., 2012; Raven, 1985). Therefore, unidentifiable specimens are considered potential SREs.

Scorpiones (scorpions) – Urodacus armatus

Scorpions is a relatively small order of arachnids, with approximately 1,700 described species (Fet & Lowe 2000). Currently, 23 species of *Urodacus* are described; however, this may represent as little as 20% of the real diversity of this genus in Australia. *Urodacus* appears to be most diverse in WA and few species are recorded east of the Great Dividing Range in eastern Australia.

Urodacus species associated with *Urodacus armatus* represent relatively small and pale scorpions. The taxonomy of this group and therefore the distribution patterns of species within this group are poorly resolved. Based on distribution patterns of species within *Urodacus*, a genus that includes widespread in addition to range-restricted species, members of the *Urodacus armatus*-group are considered potential SREs (Harewood, 2020a).

Isopod (slaters) – Buddelundia

Members of the genus *Buddelundia* belong to the most common terrestrial isopods in WA and the genus was well represented in the study area.

Buddelundia '85' is morphologically similar to *Buddelundia sulcatus* and *Buddelundia* '39', both known from the Goldfields region of WA. The species has so far only been found at L. Medcalf and is therefore considered a potential SRE based on known distribution patters of species within the genus, which includes widespread and range-restricted species (Harewood, 2020a; Harewood, 2020b).

Habitat

In terms of habitats for terrestrial invertebrates, the area in and around the Proposal includes granite outcrops with heathland, bare saline playa, depressions with samphire bush or chenopod shrubs, and various types of woodland and shrubland found in hillslopes or clay and sandy loam plains. Given their spatial isolation and restricted availability in the general landscape, the most prospective of these habitats for SRE groups are the granite outcrops, the depressions with samphire bush or saline playa, and the shrublands on hillslopes.

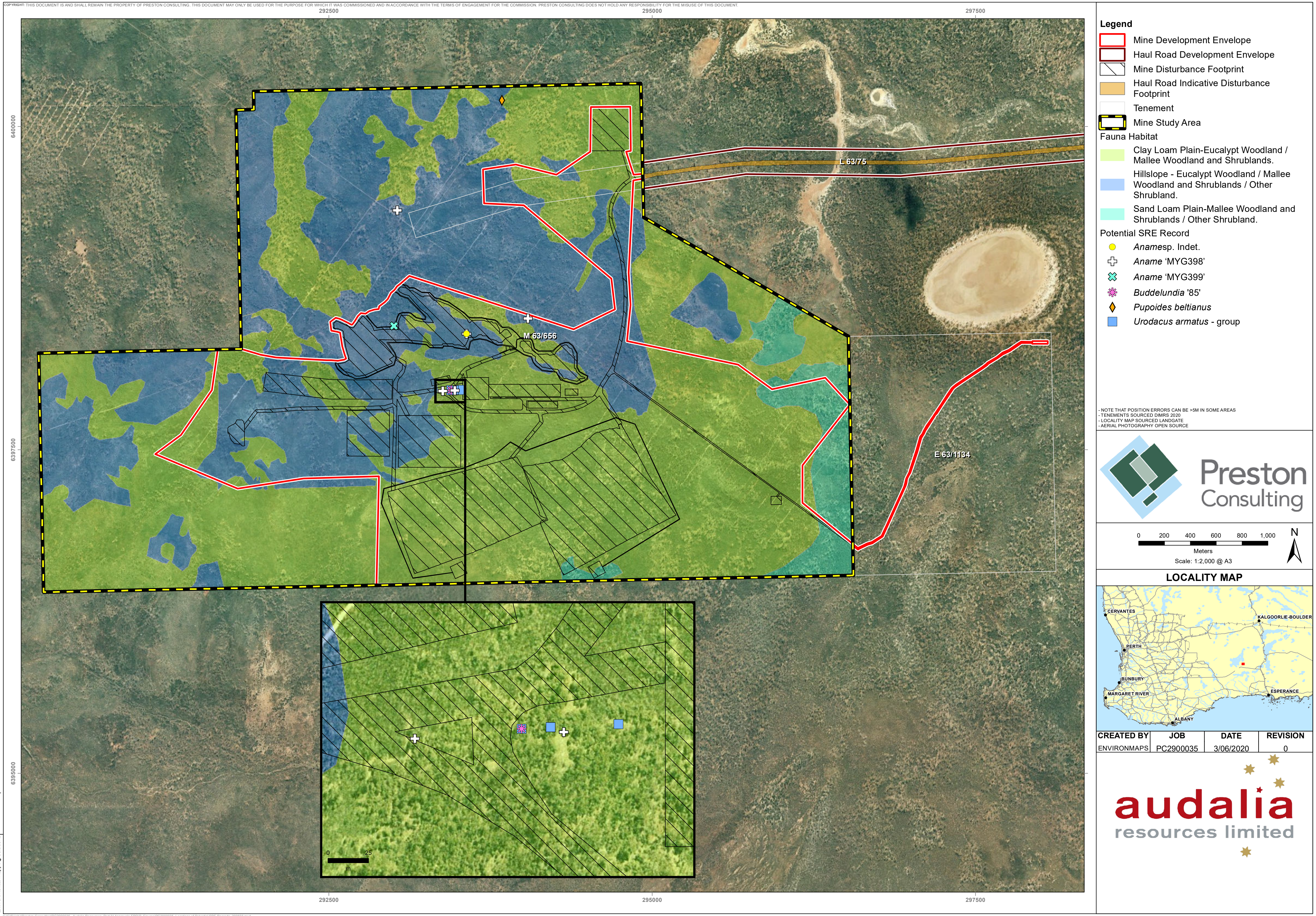


Figure 88: Locations of potential SRE records

6.3.7 Great Western Woodlands and Gondwana Link

The study areas lies within the Great Western Woodlands (Figure 19). The Great Western Woodlands is considered by The Wilderness Society to be of global biological and conservation importance as one of the largest and healthiest temperate woodlands on Earth, containing many endemic species. The region covers almost 16 million ha, 160,000 km^2, from the southern edge of the WA Wheatbelt to the pastoral lands of the Mulga country in the north, the inland deserts to the northeast, and the treeless Nullarbor Plain to the east.

The area provides an eastward connection between southwest forests and inland deserts (Gondwana Link) as well as linking the north-west passage to Shark Bay. The majority of the Great Western Woodlands is unallocated crown land (61.1%) with other interests including pastoral leases (20.4%), conservation reserves (15.4%) unallocated crown land ex pastoral managed by the DBCA (2%) and private land (approximately 1%) (Watson et. al., 2008).

No specific management strategy applies to the Great Western Woodlands, rather an approach to conservation which occurs across all land tenures and when different stakeholders work together with biodiversity in mind. The central component of this approach is to identify and conserve key large-scale, long term ecological processes that drive connectivity between ecosystems and species. The Great Western Woodlands currently includes towns, highways, roads, railways, private property, Crown Reserves, agricultural activities and mining tenements.

6.3.8 Environmental Values

The information provided in Section 6.3.1 to 6.3.7 was utilised to determine the environmental values that require assessment for this factor. Values were included for assessment based on the following parameters (from the EPA's Environmental Factor Guideline; Terrestrial Fauna):

- Fauna species listed under the EPBC Act or BC Act that were recorded or considered likely to occur within the study areas;
- Species with a restricted distribution;
- Species with a degree of historical impact from threatening processes;
- Species that provide an important function required to maintain the ecological integrity of a significant ecosystem; and
- Significant habitat types for fauna species that are important to the life history of a significant species, i.e. breeding, feeding and roosting or aggregation areas, or where they are unique or isolate habitats in the landscape or region.

Based on the parameters listed above, the following environmental values were required assessment for this factor:

- General fauna species and habitats, including several habitat types that may be used by significant fauna such as Peregrine Falcon, Western Rosella, Central Long-eared Bat, Lake Cronin Snake, Carnaby's Black Cockatoo, Western Brush Wallaby, Chuditch and Fork-tailed Swift;
- Malleefowl;
- Species that are potential pollinators for *M. aquilonaris*; and
- Potential SREs.

6.4 POTENTIAL IMPACTS

Table 44 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context.

Table 44: Potential impacts on terrestrial fauna

Environmental value	Current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General widespread fauna species and habitat	The pre-European vegetation associations within the survey area are relatively uncleared with a minimum of 97% of each type remaining. The majority of fauna habitat within the study area is currently in a state of regeneration after a series of fires in 2009/2010.	Up to 650 ha clearing of fauna habitat, which lies within the Greater Western Woodlands region and within the 'pathway' of the Gondwanalink project, including associated fragmentation impacts. Death or injury of fauna due to vehicle strike or earthmoving equipment. Fauna entrapment in evaporation pond, TSF and excavations.	Increased predation or competition from introduced fauna. Altered movements and behaviour of fauna due to haul road. Increase fire risks as a result of machinery sparks, cigarettes and other sources. Alterations to fauna behaviour (including feeding or breeding characteristics) as a result of excessive dust, light or noise emissions. Reduction in habitat health as a result of: • Establishment or spread of weed species/populations • Excessive dust	No other proposals are located in proximity to the Proposal.	Up to 650 ha of direct disturbance and fragmentation. Potential death or injury of fauna. Some indirect to fauna habitat health and fauna behavioural impacts.
Malleefowl and associated habitat	Malleefowl have a current patchy distribution of about 80% in Australia. Only one Malleefowl and an old nest mound were recorded in the Haul Road Study Area. No evidence of Malleefowl within the Mine Study Area was recorded. Some recent tracks were recorded outside the study areas.	Up to 350 ha of clearing of potential habitat. Death or injury and / or destruction of mounds during clearing and construction. Death or injury due to vehicle strike via haul trucks and other vehicle movements along the haul road.	Increased predation or competition from introduced fauna. Potential fragmentation of habitat and/or altered movements and behaviour due to 74 km haul road. Increase fire risks as a result of machinery sparks, cigarettes and other sources.	No other proposals are located in proximity to the Proposal	Up to 350 ha of direct disturbance. Potential death or injury of Malleefowl and destruction of mounds. Some indirect impacts to Malleefowl habitat health and behavioural impacts.
M. aquilonaris pollinator species	*M. aquilonaris* pollinator species are predicted to have a small range, based on the minimal genetic exchange between	Clearing of up to 5.7 ha within 100 m of *M. aquilonaris* populations	Potential fragmentation of habitat and/or altered movements and behaviour.	No other proposals are located in proximity	Clearing of up to 5.7 ha within 100 m of *M. aquilonaris* populations and

Environmental value	Current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
	M. aquilonaris populations, despite their close proximity (in some cases ~80 m). A buffer of 100 m around the *M. aquilonaris* populations is therefore predicted to contain the majority of the pollinators for *M. aquilonaris*.		Reduction in habitat health as a result of dust. Increase fire risks as a result of machinery sparks, cigarettes and other sources.	to the Proposal	potential indirect impacts
Potential SREs	The DE's were noted as containing potential SRE species Four potential species were recorded in the Mine DE and other SREs may be present The most prospective habitats for SREs are granite outcrops, the depressions with samphire bush or saline playa, and the shrublands on hillslopes.	Clearing of up to 300 ha of habitat for potential SREs within the Mine DE. Clearing of up to 350 ha within the Haul Road DE.	Potential fragmentation of habitat and/or altered movements and behaviour. Reduction in habitat health as a result of dust Increase fire risks as a result of machinery sparks, cigarettes and other sources.	No other proposals are located in proximity to the Proposal	Clearing of up to 650 ha of potential SRE habitat and potential indirect impacts.

6.5 Assessment of Impacts

The following section assesses the potential direct and indirect impacts on each environmental value identified in Section 6.4.

6.5.1 General fauna species and habitat

Direct Disturbance – Regional Scale

At a broad regional scale, the proposed 650 ha of disturbance is to occur within an area with minimal historic disturbance (more than 97% of the pre-European extent of the surrounding vegetation associations will remain after the implementation of the Proposal). In most cases this demonstrates that the disturbance of general widespread fauna habitat is unlikely to be significant, as large areas of suitable intact habitat will remain. The Proposal however lies within the Great Western Woodlands and within the 'pathway' of the Gondwanalink Project, and therefore the value of the land is that it is almost completely intact. Disturbance therefore needs to be assessed in this context.

The Great Western Woodlands is the largest remaining intact Mediterranean-climate woodland in the world and is considered to be an internationally significant area of great biological richness (DEC, 2010a). It is home to almost 300 vertebrate species and a number of threatened species (Raiter, 2016). The region also has high levels of endemism and beta diversity, comprises a significant refuge for many birds and other species that have declined or become locally extinct elsewhere, and holds considerable carbon stocks (Watson et al. 2008; Prober et al. 2010; Prober et al. 2012).

Cumulative disturbance within the Great Western Woodlands is estimated to be in the order of 69,000 ha, or 0.43% of its estimated 16 million ha extent. It currently contains 334 operating mines and has 119,303 'abandoned mines' registered within its boundary, as well as 1,310 exploration tenements, 2,826 mining tenements, and 2,938 prospecting tenements together covering 60% of the region (DEC, 2010a; DMP, 2013b). There is an estimated 150,000 km of linear infrastructure in the region with vehicle tracks make up the majority of the disturbance footprint in the Great Western Woodlands (Raiter, 2016).

The Proposal disturbance represents a very small proportion of the extent of the Great Western Woodlands (0.004%) and would make up less than 1% of the current disturbance once developed. While these percentages are small, successful rehabilitation of the Proposal and other mining projects is important to ensure the fauna values of the Great Western Woodlands are not significantly affected. Rehabilitation mitigation measures are described in Section 6.6.

Direct Disturbance – Local Scale

The Proposal will result in the direct disturbance of up to 650 ha of fauna habitat over five habitat types (Table 45 and Figure 80).

Table 45: Habitat types, extent and indicative disturbance

Fauna habitat type	Extent in Study Areas	Extent in DEs	Extent in Indicative Disturbance Footprint
Clay-Loam Plains – Eucalypt woodlands or Mallee woodlands over shrublands	14,694 ha	1,961 ha (13.3% of mapped extent)	505 ha (3.4% of mapped extent)
Hillslopes – Eucalypt woodlands or Mallee woodlands over shrublands or shrublands	1,026 ha	243 ha (23.7% of mapped extent)	80 ha (7.8% of mapped extent)
Sand-Loam Plains – Eucalypt woodlands or shrublands	3,140 ha	300 ha (9.6% of mapped extent)	57 ha (1.8% of mapped extent)
Closed Depressions – Low samphire shrubland over low open forbland on playa/bare playa	209 ha	2 ha (1.0% of mapped extent)	0.2 ha (0.1% of mapped extent)
Granite Outcrops – Heathland over sparse tussock grassland on granite outcrops	265 ha	18 ha (6.8% of mapped extent)	14 ha (5.3% of mapped extent)

Table 45 provides the following findings:

- None of the fauna habitat types are restricted to the DEs;
- More than 76% of the extent of every habitat type is located outside the DEs;
- More than 93% of the extent of the two most restricted habitat types ('Closed Depressions' and 'Granite Outcrops') are located outside the DEs;

- More than 92% of the extent of every habitat type lies outside the indicative disturbance footprint; and
- More than 94% of the extent of the two most restricted habitat types ('Closed Depressions' and 'Granite Outcrops') are located outside the indicative disturbance footprint.

Based on the above, the direct disturbance of the Proposal will not result in the significant reduction in the extent of any fauna habitat type. Given the minimal current disturbance in the area the direct disturbance of the Proposal is therefore considered unlikely to have a significant impact on the availability of habitat for fauna populations in the area.

Fragmentation

The Proposal will include 650 ha of disturbance and the construction of significant features such as mine pits, haul road and the TSF that can fragment fauna habitats. This fragmentation is however unlikely to significantly impact fauna populations given that:

- The mining area is less than 3 km across, with all mine pits less than 1.4 km in width;
- The proposed disturbance is relatively small in scale, and the surrounding habitat is not disturbed or proposed to be disturbed by other proposals;
- The haul road will not be a significant built structure, and fauna will be able to traverse across it; and
- All disturbance will be rehabilitated at the completion of mining (approximately 13 years).

Vehicle / Earthmoving Equipment Strike

Vehicle strike may lead to fauna injuries or fatalities, with the greatest risk being along the haul road. Light vehicles and haul trucks will use the haul road, however only 17 truck movements are predicted each day, which is insignificant in comparison to other roads in the area (i.e. the Coolgardie-Esperance Highway south of Norseman typically has 500 truck and vehicle movements per day (Main Roads, 2020). The noise of heavy haulage along a gravel track is also expected to result in some avoidance of the road when trucks are approaching. Audalia will implement management measures to minimise the likelihood of vehicle strike impacts (refer to Section 6.6).

There is a risk of fauna death or injury if fauna are struck by earthmoving equipment during clearing or construction of the Proposal. The majority of fauna would be expected to flee the areas to be cleared as the equipment approaches, and the clearing activities are likely to be relatively slow given the presence of woodland trees which will need to be removed and stockpiled before the remaining earthmoving equipment enters the area. It is likely however that there will be some fauna injuries or deaths during these activities. Audalia will implement management measures to minimise this likelihood (refer to Section 6.6).

Based on the above, any fauna strike impacts are likely to be rare and not significant on a local or regional scale.

Fauna Entrapment

Fauna may become trapped in the evaporation pond, TSF or other excavations. The evaporation pond and TSF will have shallow internal banks and egress mats if required to ensure that any trapped fauna are able to escape. All excavations will have ramps to allow vehicles to enter and exit and these ramps will be able to be used by any fauna that may have entered. Audalia does not intend to install fences at the Proposal.

Water pipelines will be laid on top of the existing ground surface, usually alongside access roads. These pipelines may form a barrier to small terrestrial fauna that are unable to climb over the pipelines. The barrier will not be continuous however, as earth will be placed on top of the pipeline at regular intervals to allow vehicles to cross the pipeline.

Based on the above, any fauna entrapment impacts are likely to be localised and not significant on a local or regional scale.

Introduced Fauna

Five introduced species were recorded in fauna surveys within the study areas including cats, foxes, camels, rabbits and house mice (Harewood, 2020a; 2020b). The Proposal has the potential to introduce additional species or increase the population of existing introduced species, through the following vectors:

- Food wastes at the accommodation camp or landfill; or
- Presence of cleared corridors that may be utilised by introduced fauna for access or predation.

The accommodation camp will be relatively small, and there are no other Proposal activities that would either attract introduced fauna species or aid their survival in the area. The appropriate management and disposal of food wastes (refer to Section 6.6) will ensure that food wastes do not attract fauna to the area. No pets will be brought to site.

Roads can result in increases in predator activity by providing movement pathways or improved access for predatory hunting and travel (Raiter, 2016). There are some minor roads within the mine site however the Haul Road is likely to present the greatest risk. In order to counteract this risk feral animal controls are proposed to be implemented in consultation with DBCA (refer to Section 6.6).

With the implementation of controls (refer to Section 6.6) potential introduced fauna impacts described above are expected to be able to be appropriately mitigated such that impacts are not significant on a local or regional scale.

Altered Fauna Movements and Behaviour

The Proposal will result in some barriers to native fauna movements, with the Haul Road structure presenting the largest risk given its length and required width. The Haul Road however is not proposed to be a significant structure; it will not be fenced and will be built at ground level for the majority of its length. Given the relatively low vehicle movements on this road (less than one haul truck movement per hour) native fauna are likely to be able to easily cross this structure.

The Haul Road may also be used by some native fauna as a movement pathway. This is unavoidable however given the wide-ranging fauna recorded during the surveys it is unlikely to significantly increase or otherwise alter the range of any populations.

Fire Risk

Fires are prevalent in this area from almost year to year and evidence of several fires in the area has been noted by Botanica (2020c). The Proposal may however increase of risk of fires starting as a result of machinery sparks, cigarettes and other sources. This risk will be reduced as far as practicable by the implementation of specific mitigation measures (refer to Section 6.6), and may be counteracted by the presence of fire-fighting equipment on site, which will allow small fires to be controlled before they become uncontrolled.

With the implementation of controls (refer to Section 6.6) potential increased risks to fauna from fire are expected to be able to be appropriately mitigated such that impacts are not significant on a local or regional scale.

Dust, Light and Noise Emissions

Indirect impacts associated with dust emissions and weeds have been discussed in detail in the Flora and Vegetation section (Section 5). As these potential impacts are similar (i.e. a potential decline in vegetation / fauna habitat health), an assessment of these potential indirect impacts has not been repeated in this section.

The Proposal will produce low levels of artificial light and noise emissions. The main source of noise and light emissions will be the Process Plant (24-hour operations), which covers only several hectares and is located away from the majority of significant fauna species recorded. Trucks moving along the haul road will produce noise emissions however this will occur less than once per hour. Nevertheless it is expected that some fauna will keep some distance from the haul road while haul trucks are utilising the road. With the implementation of controls (refer to Section 5.6 and 6.6) potential increased risks to fauna from dust, light or noise emissions are expected to be able to be appropriately mitigated such that impacts are not significant on a local or regional scale.

6.5.2 MALLEEFOWL

Up to 350 ha of clearing of potential Malleefowl habitat is required to develop the haul road. This direct disturbance may lead to Malleefowl injuries or fatalities and destruction of Malleefowl mounds. However, disturbance within the Haul Road Study Area is not expected to be significant as evidence of Malleefowl was only found in a small area and no active mounds were detected. Management controls, including more surveys will be prepared and implemented prior to clearing and construction (refer to Section 6.6).

No impacts to Malleefowl within the Mine Study Area are expected as no evidence of Malleefowl using the Mine Study Area and in particular no evidence of breeding (i.e. nest mounds recent or old) was observed. Rocky areas in proposed open pit locations appear totally unsuitable for Malleefowl habitat. The state of most of the vegetation (recently burnt) also makes much marginal in quality as habitat.

Vehicle strike via haul trucks and other vehicle movements along the haul road may also lead to Malleefowl injuries or fatalities. This impact is expected to be rare given the low usage of the road, as well as the implementation of measures to minimise vehicle strike impacts (i.e. vehicle speed limits, minimising driving at dawn, dusk or night as far as practicable).

Increased predation or competition from introduced fauna has the potential to occur as four introduced species were recorded in fauna survey within the Haul Road Study Area (Harewood, 2020b). However, the Proposal does not provide any significant vectors for increases in introduced fauna species; the accommodation camp will be relatively small, and there are no other Proposal activities that would either attract introduced fauna species or aid their survival in the area. Mitigation measures and/or eradication programmes will be implemented (refer to Section 6.6).

The proposed haul road disturbance is unlikely to fragment Malleefowl habitat and/or altered movements and behaviour of Malleefowl, given the wide ranging nature of the fauna in the region and that the haul road will not create physical barriers to movement for Malleefowl.

Fires are prevalent in this area from almost year to year and evidence of several fires in the area has been noted by Botanica (2020c). The Proposal may however increase of risk of fires starting as a result of machinery sparks, cigarettes and other sources. This risk will be reduced as far as practicable by the implementation of specific mitigation measures (refer to Section 6.6), and may be counteracted by the presence of fire-fighting equipment on site, which will allow small fires to be controlled before they become uncontrolled. With the implementation of controls (refer to Section 6.6) potential increased risks to fauna from fire are expected to be able to be appropriately mitigated such that impacts are not significant on a local or regional scale.

6.5.3 M. AQUILONARIS POLLINATORS

This assessment is based on two pollinator values:

1. *M. aquilonaris* pollinators – the pollinator bees or other insect individuals that are predicted to inhabit the *M. aquilonaris* sub-populations or immediate surrounds (within 100 m); and
2. Broader bee population – the regional population that does not specifically inhabit the *M. aquilonaris* sub-populations or immediate surrounds but may visit on occasion and provide breeding opportunities and genetic exchange for the *M. aquilonaris* pollinators.

Direct Disturbance

The largest number of *M. aquilonaris* pollinators are predicted to utilise habitat within and immediately surrounding the sub-populations, with numbers decreasing with distance. Genetic data on *M. aquilonaris* suggesting limited pollen exchange occurs between the sub-populations, which suggests that the sub-populations are isolated from the perspective of pollen vectors (Prendergast, 2019). Given the sub-populations are separated by as little as 80 m in some cases, *M. aquilonaris* pollinator species are predicted to have a small range, and a buffer of 100 m around the *M. aquilonaris* sub-populations is therefore predicted to contain the majority of the pollinators for *M. aquilonaris*.

The Mine DE intersects with 3.2 ha of this 100 m buffer and 1.2 ha is predicted to be disturbed by the Proposal. This equates to 3.0% of the 40.3 ha that makes up the *M. aquilonaris* sub-populations and the associated 100 m buffer (Figure 89).

The proposed disturbance will occur within the buffer of *M. aquilonaris* sub-population 1b and 1c. When assessed that this scale, the Proposal is predicted to disturb 0.46 ha of the buffer around sub-population 1b, and 0.77 ha of the buffer around sub-population 1c.

A disturbance of 0.46 ha represents 8.7% of the 5.28 ha extent of the *M. aquilonaris* sub-population 1b and associated 100 m buffer. However, given there is more than 60 m between the mine pit and sub-population 1b it is likely that the pollinators that currently inhabit habitat within the proposed mine pit footprint visit this sub-population infrequently in comparison to those within or close to the sub-population. An abandonment bund also lies between the mine pit and sub-population 1b however only 0.07 ha of disturbance is required for this bund, equating to only 1.3% of the extent of the *M. aquilonaris* sub-population 1b and associated 100 m buffer.

A disturbance of 0.77 ha represents 8.1% of the 9.46 ha extent of the *M. aquilonaris* sub-population 1c and associated 100 m buffer. However, given there is more than 70 m between the mine pit and sub-population 1c (and 50 m between the abandonment bund) it is likely that the pollinators that currently inhabit habitat within the proposed abandonment bund and mine pit footprint visit this sub-population infrequently in comparison to those within or close to the sub-population.

The Proposal will result in an estimated 300 ha of disturbance of habitat that is utilised by the broader bee population, which provides genetic exchange with the *M. aquilonaris* pollinators. This disturbance is predicted to be in the order of 10% of the surrounding habitat, at distances up to 3 km from the *M. aquilonaris* sub-populations (at distances greater than 3 km the percentage decreases). Given an estimated minimum 90% of the surrounding habitat will be retained after the implementation of the Proposal it is considered unlikely that the regional bee population will be significantly impacted such that the viability of the *M. aquilonaris* pollinators is threatened.

Fragmentation

The Proposal disturbance described above and the construction of significant features such as mine pits, haul road, evaporation ponds and the TSF can fragment regional pollinator habitats. Given the short-range of native bee species this fragmentation is likely to be most significant to the south-east of the *M. aquilonaris* sub-populations, where mine pits and mining infrastructure will fragment this habitat.

There is however no disturbance proposed in the remainder of the surrounding habitat (i.e. to the north, west and north-west of the *M. aquilonaris* sub-populations, and these habitats will remain unfragmented for the life of the Proposal. The fragmentation of a portion of this regional habitat is unlikely to result in significant impacts to the regional bee population such that the viability of the *M. aquilonaris* pollinators is threatened.

Dust Emissions

As discussed in Section 5.5, the Proposal will result in dust emissions and deposition within surrounding habitat. Using the same conservative indirect impact trigger value of 8 g/m^2/month, the Proposal may result in a reduction in health of 2.91 ha of the remaining *M. aquilonaris* pollinator habitat. This equates to 7.2% of the 40.3 ha that makes up the *M. aquilonaris* sub-populations and the associated 100 m buffer (Figure 65).

The potential dust deposition health impacts are predicted to occur within the buffer of *M. aquilonaris* sub-population 1b and 1c. When assessed that this scale, the Proposal is predicted to affect:

- 1.28 ha of the sub-population 1b pollinator habitat, equivalent to 24.2% of the combined 5.28 ha extent; and

- 1.63 ha of the sub-population 1c pollinator habitat, equivalent to 17.2% of the combined 9.46 ha extent.

Fire Risk

The Proposal may increase of risk of fires starting, as a result of machinery sparks, cigarettes and other sources. This risk will be reduced as far as practicable by the implementation of specific mitigation measures (refer to Section 6.6), and may be counteracted by the presence of fire-fighting equipment on site, which will allow small fires to be controlled before they become uncontrolled. Given that this equipment will be kept at the mine site during normal operations, it is likely that any fire outbreaks within *M. aquilonaris* pollinator habitat would be controlled quickly.

With the implementation of controls (refer to Section 6.6) potential increased risks to *M. aquilonaris* pollinators from fire are expected to be able to be appropriately mitigated such that impacts are not significant.

Summary

The Proposal is predicted to have the following impacts on *M. aquilonaris* pollinator habitat:

- 1.2 ha of direct disturbance (3.0% of extent);
- 0.46 ha of direct disturbance and 1.28 ha of potential dust deposition health impacts within *M. aquilonaris* sub-population 1b pollinator habitat, equivalent to 33.0% of the combined 5.28 ha extent;
- 0.77 ha of direct disturbance and 1.63 ha of potential dust deposition health impacts within *M. aquilonaris* sub-population 1c pollinator habitat, equivalent to 25.4% of the combined 9.46 ha extent; and
- Up to a 10% impact on regional native bee habitat (within 3 km of the *M. aquilonaris* sub-populations).

These impacts are unlikely to be considered significant from a fauna perspective (i.e. the EPA objective for terrestrial fauna is able to be met), however there are subsequent impacts to *M. aquilonaris*, which are discussed in detail in Section 5.5.

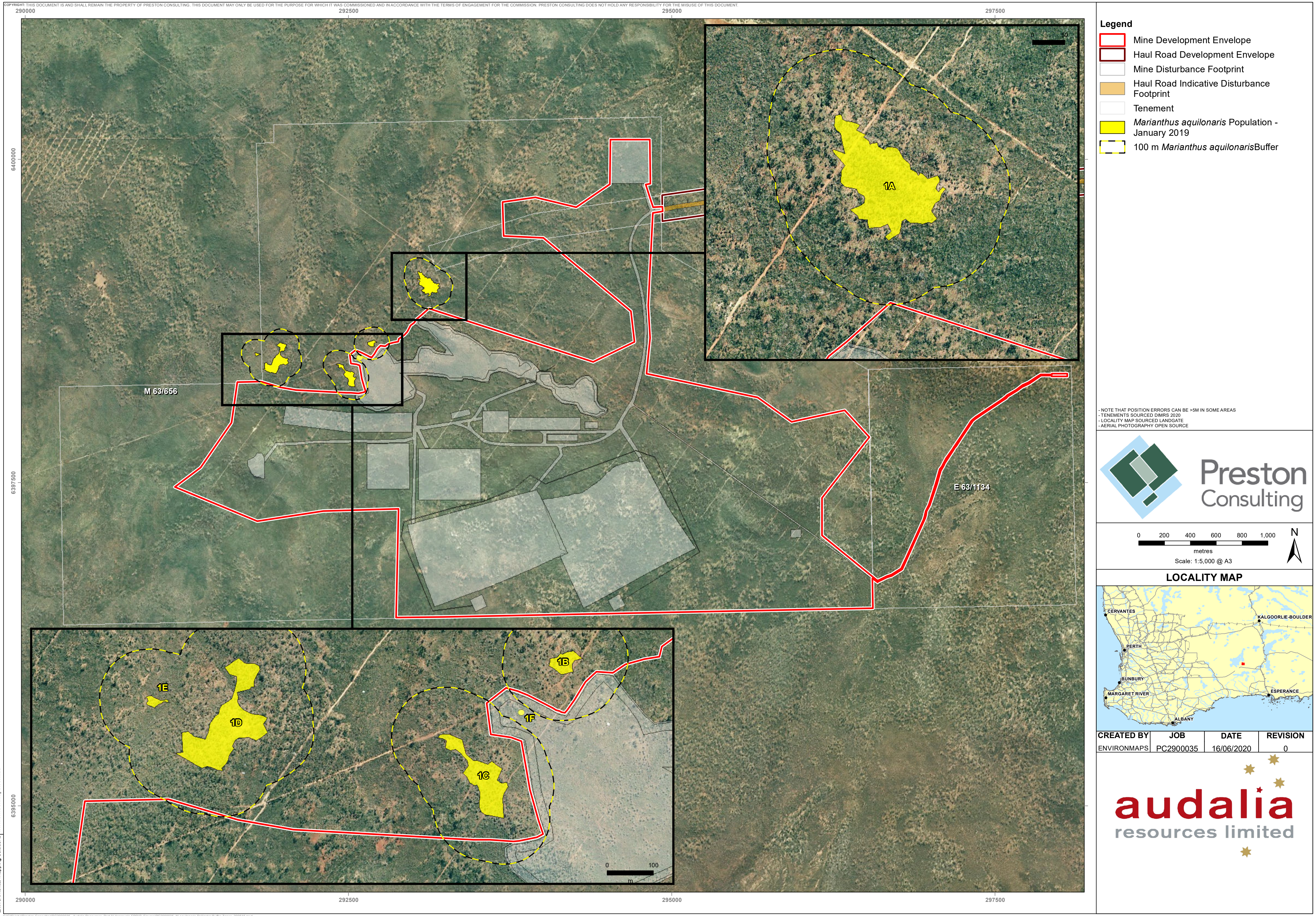


Figure 89: Potential impacts to M. aquilonaris pollinator habitat

6.5.4 Potential Short-range Endemic Fauna

The desktop survey conducted by Bennelongia (2020a) identified that 34 SRE species had the potential to occur within the DEs. Four potential SRE fauna were recorded within the Mine DE and two species were recorded within the indicative disturbance footprint of the Proposal (Harewood, 2020a). SRE surveys were not conducted within the Haul Road DE however it is likely that some potential SRE fauna may occur there also.

In terms of habitats for terrestrial invertebrates, the area in and around the Proposal includes granite outcrops with heathland, bare saline playa, depressions with samphire bush or chenopod shrubs, and various types of woodland and shrubland found in hillslopes or clay and sandy loam plains. Given their spatial isolation and restricted availability in the general landscape, the most prospective of these habitats for SRE groups are the granite outcrops, the depressions with samphire bush or saline playa, and the shrublands on hillslopes.

There is a great deal of taxonomic uncertainty in the identifications of the records captured in the desktop search, and it is possible that this results in an inflation of the species numbers. However, it is clear that a diverse community of potentially restricted species occurs within the broad region of the Proposal, and the DEs almost certainly contain at least some SRE species. Given the small size of the DEs however, it is unlikely that any SRE species will be restricted to the DEs, and the possibility of SRE species occurring only within the disturbance footprint of the Proposal is negligible, given the small scale of disturbance (Bennelongia, 2020a). Nevertheless, without conducting an appropriate survey to determine exactly what SRE species are present, it is difficult to evaluate the level of risk that the Proposal poses to the conservation of SRE invertebrates. To address this, a detailed SRE survey is planned at the Proposal, with the results to be made publicly available in 2021 during the response to public submissions.

6.6 Mitigation

Audalia has mitigated the potential impacts to this factor according to the mitigation hierarchy: avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

6.6.1 Avoid

The key avoidance mechanism implemented by Audalia was the design of the development envelopes to avoid key environmental features. Audalia has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid the majority of *M. aquilonaris* pollinator habitat, which was excluded from development envelopes by relocating the mine pits.

6.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to terrestrial fauna are minimised:

1. **Implement industry best practice management measures for terrestrial fauna:**
    a. Vegetation clearing will be managed through internal ground disturbance procedures;

   b. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operator to minimise clearing;
   c. Progressive clearing will be undertaken;
   d. Raised blade disturbance will be conducted where practicable on tracks to minimise vegetation removal;
   e. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
   f. Water or dust suppressants will be applied to disturbed areas and product transfer/storage areas as required to minimise dust generation;
   g. Emergency response capabilities will be maintained to prevent fire outbreaks where possible;
   h. Weed hygiene and management measures / procedures will be implemented to prevent spread of weeds and the introduction of new weed species as a result of construction and operation;
   i. Any trenches will be dug with shallow interior slope angles or exit points to allow fauna escape;
   j. Any trenches will be progressively opened and closed;
   k. Fauna egress mechanisms will be installed at all trenches, turkeys nests or water ponds;
   l. Any open trenches (if required) will be inspected less than two hours after sunrise for the presence of trapped fauna;
   m. Training will be provided to ensure that fauna are not fed by site personnel;
   n. Food wastes will be stored in bins that are not easily accessible to fauna;
   o. Low noise equipment will be used where practicable;
   p. All incidents resulting in fauna injury or death will be reported internally;
   q. Vehicle speed limits will be set and enforced;
2. **Obtain and comply with the following approvals:**
   a. Ministerial Statement to be issued under Part IV of the EP Act;
   b. Works Approval(s) and Licence to be issued under Part V of the EP Act;
   c. MP to be approved under the Mining Act;
3. **Implement the Dust Control Management Strategy provided in Appendix 10**;
4. **Prepare and implement an Introduced Fauna Management Plan**. The plan will include commitments to control the presence of introduced fauna, including:
   a. Reporting of introduced fauna sightings;
   b. Annual targeted introduced fauna survey to determine if there have been any increases in population or number of introduced fauna species;
   c. Introduced fauna controls such as trapping will be implemented in consultation and collaboration with DBCA;
   d. Pets will not be allowed on site;
   e. Food wastes will be stored in bins that are not easily accessible to introduced fauna;
   f. Introduced fauna are not to be fed or otherwise interacted with by site personnel;
5. **Conduct pre-clearance surveys for active Malleefowl mounds**. If an active mound is located it will either be avoided or will only be disturbed when no longer in use;
6. **Conduct a detailed SRE survey within the DEs and surrounds -** to characterise the potential SRE species and habitats that may occur, and assess the impacts of the Proposal

on SRE species. Avoidance and mitigation measures are to be implemented to ensure impacts to SRE species are not significant;

7. **Conduct an additional *M. aquilonaris* pollinator survey during peak flowing season**. The survey results will be used to:
    a. Improve knowledge of insect pollinators for this species;
    b. Inform the flora species composition to be implemented in rehabilitation to ensure suitable pollinator habitat is reinstated; and
    c. Inform any additional mitigation or rehabilitation measures that could be implemented at the Proposal to further reduce the potential impacts to pollinator species.

6.6.3 Rehabilitate

An interim MCP has been prepared to accompany this ERD (Appendix 4) which was developed according to DMIRS Guidelines (2020a; 2020b). The MCP describes the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase including**:**

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks for each of the mine domains; and
- Completion criteria, monitoring and reporting during closure.

The key rehabilitation measures in the MCP that relate to terrestrial fauna are summarised below:

1. All infrastructure will be removed from site;
2. Any residual salt within the evaporation ponds will be excavated and either placed in the bottom of the mine pit or taken off site;
3. All disturbance areas apart from the mine pit and TSF slopes will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated;
4. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed introduction;
5. Flowering plants will be included in seeding to ensure pollinator habitat is adequately reinstated;
6. All depressions will be shaped to prevent the formation of new semi-permanent water sources;
7. All surface water drainage diversions will be rehabilitated to a natural form; and
8. All surface water crossings will be reinstated by removing drainage infrastructure and reshaping as required.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to the construction of the Proposal and will be reviewed and revised every three years.

6.7 Predicted Outcome

The EPA's environmental objective for this factor is "protect terrestrial fauna so that biological diversity and ecological integrity are maintained." In the context of this objective: "ecological integrity" is listed as the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements (EPA, 2020a).

Audalia has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however some direct and indirect impacts to terrestrial fauna are unavoidable. The Proposal will result in the direct disturbance of up to 650 ha of fauna habitat, which includes habitat that may be utilised by significant fauna. All of these habitats are widely distributed throughout the region and species that potentially use the Proposal area have relatively wide ranging distributions and/or will persist in adjoining unaffected areas given the presence to extensive areas of similar habitat nearby.

The Proposal will have direct and indirect impacts on pollinator habitat for *M. aquilonaris*, which is considered under the Flora and Vegetation factor (Section 5).

In summary, the resultant potential impacts to terrestrial fauna are not expected to be significant given that:

- The Proposal is located in a remote area with only minor disturbance associated with historic mining exploration;
- Only a small portion of each mapped fauna habitat type will be impacted;
- SRE species are unlikely to be restricted to the proposed disturbance footprint (to be confirmed during detailed field surveys currently underway);
- Other indirect impacts are not expected to be significant or are easily mitigated; and
- Rehabilitation will occur as described in the MCP to be assessed under the Mining Act.

The implementation of the proposed mitigation is expected to ensure that no significant residual impacts occur.

Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor.

7 SUBTERRANEAN FAUNA

7.1 EPA Objective

The EPA Objective for this key environmental factor is to protect subterranean fauna so that biological diversity and ecological integrity are maintained.

7.2 Policy and Guidance

Relevant EPA guidance documents for subterranean fauna are listed below:

- Statement of Environmental Principles, Factors and Objectives (EPA, 2020a);
- Environmental Factor Guideline for Subterranean Fauna (EPA, 2016i);
- Technical Guidance: Subterranean Fauna Survey (EPA, 2016j); and
- Technical Guidance: Sampling Methods for Subterranean Fauna (EPA, 2016k).

Other relevant guidance documents for subterranean fauna are listed below:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Commonwealth of Australia, online resource, 2018);
- Australian Groundwater Modelling Guidelines. Waterlines Report (Barnett et al., 2012);
- Western Australia Water in Mining Guideline. Water licensing delivery report series. Report No. 12 (Department of Water (DoW), 2013);
- State Water Quality Management Strategy Document No. 6. (Government of WA, 2004); and
- *Rights in Water and Irrigation Act 1914* (RIWI Act).

7.3 Receiving Environment

The information in this section has been sourced from the following report, provided in Appendix 6:

- Medcalf Project: Assessment of Subterranean Fauna Values (Bennelongia, 2020b).

7.3.1 Survey Effort

Bennelongia (2020b) conducted a desktop review of habitat information and relevant biological records, and a field survey to appraise the potential values of the Proposal and surrounds in the context of subterranean fauna (stygofauna and troglofauna).

Desktop Review

Several information sources were utilised in order to characterise potential subterranean fauna habitats and to appraise the prospectivity of the mining areas and immediate surrounds for subterranean fauna:

- Groundwater Supply Investigation, Medcalf Vanadium Project (GRM, 2020b);
- Geological mapping, including the Lake Johnston 1:250,000 map sheet (Gower and Bunting, 1971) and composite regolith mapping (Marnham and Morris, 2003);
- Description of local geology (memorandum to Audalia from B. Butler, 2020a);

- Palaeovalley mapping (Bell et al., 2012);
- Diamond drill core photographs and associated lithology logs in proposed mine pits; and
- Hydrogeological desktop report for the Proposal area and surrounds (GRM, 2015).

The biological records of both stygofauna and troglofauna were compiled from Western Australian Museum and Bennelongia databases, within a search area with a radius of approximately 100 km from the proposed mine pits.

Field Survey

A field survey of subterranean fauna was undertaken by Bennelongia between October 2019 and April 2020, with additional traps set in June 2020. Sampling for troglofauna via scraping and trapping was conducted at 27 uncased exploration drill holes located in and around the proposed mine pit footprints (Figure 90). Nine bores in the potential water supply borefield to the northeast, east and southeast of the mine area were sampled for stygofauna via net hauling. All stygofauna samples were outside the mine area.

Stygofauna

Stygofauna were sampled at each bore using weighted plankton nets. Six hauls were taken at each site, three using a 50 µm mesh net and three with a 150 µm mesh net. The net was lowered to the bottom of the hole, jerked up and down to agitate the benthos (increasing the likelihood of collecting benthic species) and then retrieved slowly through the water column. Substrate in the terminal vial of the net was collected after each haul, preserved in ethanol and kept on ice in the field prior to refrigeration at the conclusion of work.

In the laboratory, samples were elutriated and sieved into size fractions using 250 µm, 90 µm and 53 µm screens. Samples were sorted under a dissecting microscope and stygofauna specimens identified to species level where possible using available keys and species descriptions.

Basic In situ water quality parameters – temperature, electrical conductance (EC) and pH – were measured for each bore with a TPS WP-81 field meter, using water collected from the top of the water table with a bailer. Standing water level was measured using a Heron water level meter.

Troglofauna

To check whether conclusions of the desktop review were correct, a two-season field survey of subterranean fauna was undertaken by Bennelongia. The first round was conducted between October 2019 and April 2020, whereas the second round was conducted between May and August 2020. Sampling for troglofauna via scraping and trapping was conducted at a total of 78 uncased exploration drill holes located in, around and up to 1.7 km away from proposed mine pit footprints.

In addition, nine bores in the potential water supply borefield to the northeast, east and southeast of the mine area were sampled for stygofauna via net hauling. Details of the holes and bores sampled are provided in Figure 90. The distribution of troglofauna samples relative to mine pit footprints is summarised in Table 3. All stygofauna samples were outside the mine area. Sampling was conducted by Anton Mittra, Mike Scanlon and Jim Cocking. Specimens were identified by Jane McRae.

Each hole was sampled via scraping and two traps were also set in each hole. Scrape samples (scrapes) were collected immediately prior to setting traps using a troglofauna net (150 µm mesh) that was lowered to the bottom of the hole (or to the watertable) and scraped back to the surface along the walls of the hole. Each scrape comprised at least four sequences of lowering and retrieving the net to give adequate coverage over the inner surface of the hole. Scrapes were preserved in ethanol and kept on ice in the field prior to refrigeration at the conclusion of work.

Cylindrical PVC traps with numerous apertures were baited with moist leaf litter and lowered on nylon cord to depths considered to give the best sampling coverage along the length of the hole. The leaf litter bait had been collected from either the Yilgarn or Pilbara, wetted, allowed to decompose over weeks or months and sterilised via microwaving. Holes were capped at the surface during trap deployment to reduce the collection of surface invertebrates. Due to travel restrictions resulting from bushfires and other scheduling issues, troglofauna traps remained in the ground for approximately six months, as opposed to the usual two months. After the trapping period, traps were carefully pulled out of each hole and the contents placed in zip lock bags, allowing enough oxygen for transit back to the laboratory. Scrape and trap samples within the same site were treated as sub-samples of a single sample for reporting purposes.

In the laboratory the preserved contents of scrapes were screened into size fractions (250 µm and 90 µm) to improve sorting efficiency and sorted under a dissecting microscope to collect animals. Troglofauna were extracted from the leaf litter in traps using Tullgren funnels under incandescent lamps: light and heat from the lamps drives troglofauna (and other invertebrates) out of the litter towards the base of the funnel and into a collection vial containing 100% ethanol. The contents of each collection vial were sorted under a dissecting microscope. Litter from each funnel was also examined under a microscope for any remaining animals.

Specimens were examined for troglomorphic characteristics and, if troglofauna, identified to species or morphospecies level using existing taxonomic frameworks. Where a specimen could not be placed in a described species, it was assigned a morphospecies code (unless juvenile).

<u>Water Quality</u>

GRM (2020a) sampled seven bores in and around a borefield to the east of the mine pits as part of the water supply investigation for the Proposal (refer to Section 9 – Inland Waters). Water quality characteristics from this sampling was provided to Bennelongia to inform their habitat prospectivity assessment.

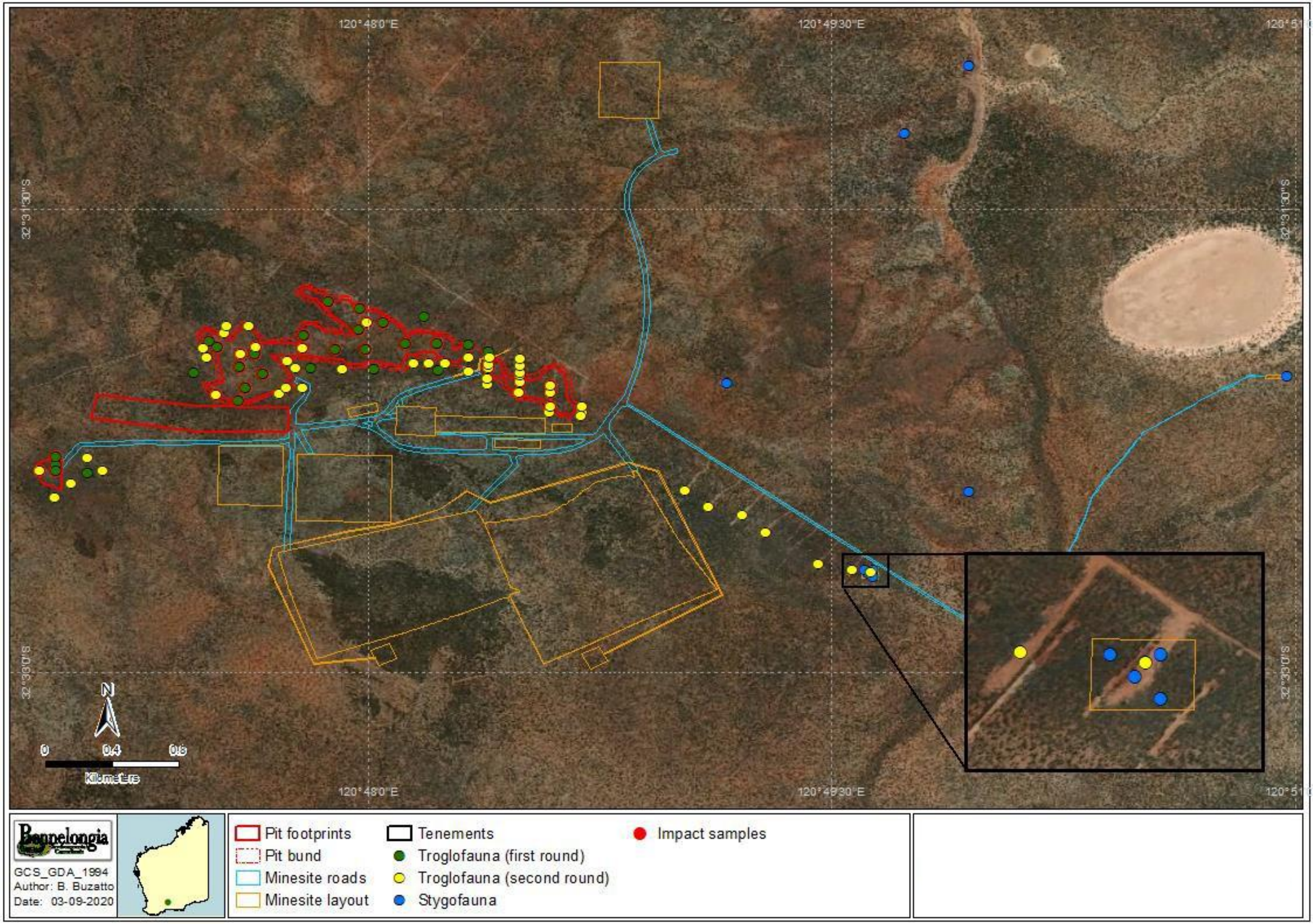


Figure 90: Distribution of troglofauna holes scape sampled (Oct 2019 to Apr 2020) and water bores sampled for stygofauna (Apr 2020)

7.3.2 Desktop Records

Stygofauna

The desktop search did not identify any records of stygofauna species within the 100 km search area. The closest records of stygofauna are over 130 km southwest of the Proposal, where 8 - 10 species have been collected, including a nematode, an oligochaete, a syncarid and four species of copepod.

Troglofauna

At least five species of troglofauna have previously been recorded within the 100 km radius search area (Table 46). These species were recorded by Bennelongia in 2012 at Mt Henry, approximately 90 km east-north-east of the Proposal and included two pseudoscorpions, one silverfish, one isopod and one symphylan (Bennelongia, 2013). The primary habitat from which these species were collected appears to be BIF.

It is unlikely that these species have large ranges and they were considered unlikely to occur at the Proposal. However, while indicative of only a moderately-rich assemblage, the records from Mt Henry show that mineralised deposits in the southern Yilgarn are prospective for troglofauna, particularly where adequate underground spaces have developed (Bennelongia, 2020).

Table 46: Troglofauna species recorded in the search area (all at Mt Henry)

Higher Classification	Lowest Identification	Total no. of holes
Arachnida		
Pseudoscorpiones		
Chthoniidae	*Austrochthonius* sp.	1
	Tyrannochthonius sp. B25	1
Insecta		
Zygentoma		
Nicoletiidae	*Trinemura* sp. B23	2
Malacostraca		
Isopoda		
Armadillidae	*Armadillidae* sp. B08	1
Symphyla		
Cephalostigmata		
Scutigerellidae	*Scutigerella* sp. B05	1

Listed Species and Communities

No listed subterranean communities occur in the vicinity of the Proposal, nor are there records of listed subterranean species.

7.3.3 Habitat

Troglofauna occupy subterranean spaces, such as alluvial interstices, voids and fissures, while stygofauna inhabit water held by such structures. Stygofauna sometimes occur in the alluvium of hyporheic zones – the confluence of groundwater and surface-water habitats – as well as in groundwater-fed springs. Geology and hydrogeology are significant drivers of the distributions of subterranean species and communities (Eberhard et al. 2005; Hose et al. 2015).

Several information sources provide a basis for characterising potential habitats and appraising the prospectivity of the Proposal and immediate surrounds for subterranean fauna:

- Groundwater report based on exploration drilling (GRM, 2020b);
- Geological mapping, including the Lake Johnston 1:250,000 map sheet (Gower and Bunting, 1971) and composite regolith mapping (Marnham and Morris, 2003);
- Description of local geology (memorandum to Audalia from B. Butler, 2020a);
- Palaeovalley mapping (Bell *et al.,* 2012);
- Diamond drill core photographs and associated lithology logs in proposed mine pits;
- Hydrogeological desktop report for the Proposal and surrounds (GRM, 2015).

Geology

The geology of the Mine DE and surrounds is shown in Figure 91. The Proposal lies in the Archaean-aged Lake Johnston greenstone belt in the Yilgarn Craton. The belt extends approximately 110 km trending north-northwest and contains komatiite lava flows, subvolcanic intrusions, mafic volcanic rocks, felsic volcanic rocks, BIF and sedimentary rocks.

Target mineral deposits are hosted by the Medcalf layered sill, which is a flat-lying igneous body that has intruded parallel to the enclosing basalts. The sill consists of upper gabbroic, middle pyroxenite and lower amphibolite zones.

The bedrock geology is widely masked by lateritic duricrust, deep oxidation and transported material including lacustrine, alluvial and colluvial deposits (GRM, 2015). The regolith and weathered bedrock extend to depths of approximately 60 - 80 m and fresh rock was not encountered during exploration drilling (hole depths of up to 90 m). Three or four mine pits containing vanadium, titanium and iron mineralisation have been identified at the Proposal – Vesuvius, Fuji, Egmont and Pinatubo. Vanadium, titanium and iron have been concentrated in a pyroxenite unit, which has been subsequently enriched through weathering and regolith-formation. The deposits are deeply weathered, with over 60 m of saprolite showing vertical zonation of weathering minerals. The lateritic weathering profile has four zones (from shallowest to deepest): lateritic residuum, mottled zone, saprolite and saprock. The mapped geological units within each of the mine pits continue outside the pits, indicating the potential for habitat connectivity (Figure 91).

Diamond core photographs and associated lithological logs demonstrate cavity development in mineralised zones at depths up to about 40 m within the proposed mine pits. Cavities several centimetres across comprise up to 10% (but usually less) of some mineralised lithologies as a result of clay removal.

Available geological mapping does not identify any substantial calcrete bodies in the vicinity of the Mine DE, although moderately large areas identified as Qpl ('alluvium and colluvium – clay, loam and silt, calcareous in part; quartz, ironstone gravel, weathered rock float, gilgai') occur within and near the mining areas and may contain some calcrete, particularly in the palaeochannel (Figure 91).

Hydrogeology

The regional hydrogeology is characterised by low relief and palaeodrainage draining to the north-east underlain by Archaean sequences. Aquifers typically occur in regional, catchment-controlled fresh and fractured rock aquifers, which are most common in mafic, ultramafic and granitic rocks; Tertiary palaeochannel sands, which typically provide the largest source of regional groundwater; and surficial deposits of laterite, alluvium and calcrete (GRM, 2015). On a regional scale, groundwater salinity is variable, but typically freshest (e.g. 1,000 - 5,000 mg/L TDS) at the edges of catchment divides and in shallow alluvial and calcrete aquifers. Deeper aquifers in palaeochannel sands and fractured rock are typically saline to hypersaline.

Exploration drill holes within proposed mine pits to depths of 90 m did not intersect the water table and mine dewatering is not required for the Proposal. Groundwater levels are expected to be closer to surface away from the proposed pits in areas of lower relief, particularly towards the Lefroy palaeovalley that encroaches into the Mine DE to the east and north-east (Figure 91).

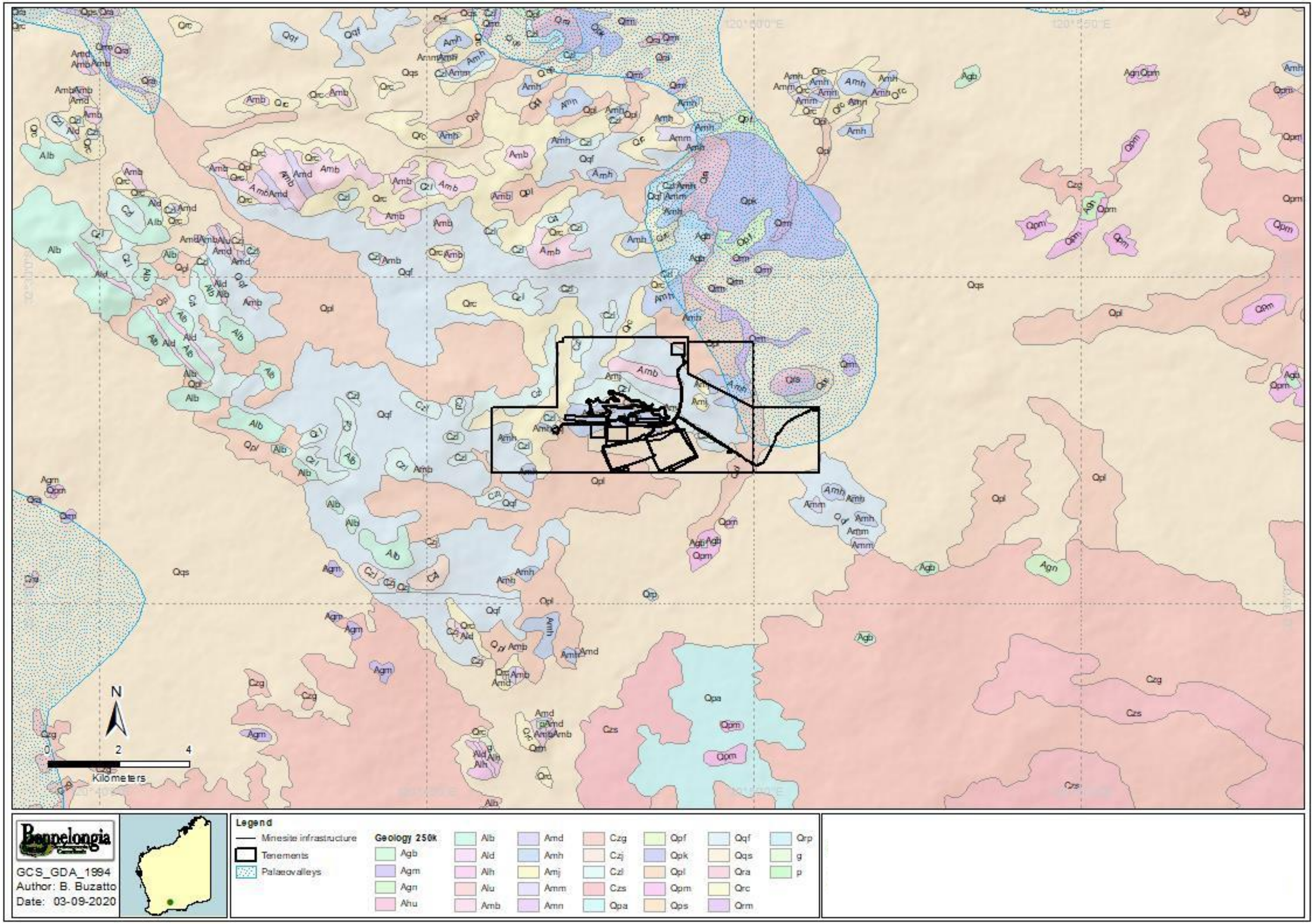


Figure 91: Geology of the mining area and surrounds.

Water Quality

Based on recent groundwater exploration drilling, aquifers in the vicinity of the Proposal occur in palaeochannel sands and deeper fractured rock. Water quality appears to be saline to hypersaline in both aquifer types. Palaeochannel aquifers appear to be acidic (pH values as low as 3.7) while those in fractured rock are circumneutral (GRM, 2020b).

Water quality parameters collected during water bore drilling (GRM, 2020b) was provided to Bennelongia for seven bores (Figure 90) in and around the borefield to the east of proposed mine pits. The data show circumneutral pH for the most part, with the exception of bore MWH003, which had lower pH of 3.7 in shallow sands and 3.8 in deeper weathered rock.

Electrical conductance in the bores was saline to hypersaline, ranging from 54,000 µS cm-1 in the Driller's Bore, to 170,000 µS cm-1 in MWH009 (Table 47). While stygofauna have previously been recorded in very saline aquifers (e.g. Schulz *et al*. 2013), the assemblages in such habitats typically comprise few species, if present at all.

Table 47: Water bore information

Bore ID	SWL (mbgl)	Slotted Interval (mbgl)	Aquifer type	pH	EC (µS cm^{-1})
MWH001	17.43	6-66	Fractured bedrock	7.2	140,000
MWH003	6.48	18-27	Sand	3.7	100,000
		33-39	Weathered breccia	3.8	110,000
MWH009	9.45	6-66	Fractured bedrock	7	170,000
MWH012	23.48	18-54	Fractured bedrock	7.6	89,000
MWH013	TBC	18-54	Fractured bedrock	7.9	55,000
MWH014	TBC	18-54	Fractured bedrock	7.6	56,000
Driller's bore	24	Unknown		7.7	54,000

Prospectivity for Stygofauna

The paucity of stygofauna records inside the desktop search area is likely to be, at least in part, an artefact of the very low historic sampling effort targeting stygofauna in the region. By the same token, in the context of habitat availability as interpreted from geological and hydrogeological information, it is considered that a rich stygal assemblage is unlikely to occur within the Mine DE. Prospectivity for stygofauna in the proposed pits and other areas with relatively high elevation is limited by the great depths to water, as suggested by exploration drilling (up to 90 m), which did not intersect groundwater. While the analogy between the southern Yilgarn and Pilbara is not certain, Halse *et al.* (2014) reported low yields of stygofauna in the Pilbara where depth to water was greater than about 30 m (although animals were present in lower numbers at greater depths).

Although not intersected by exploration drilling, geologies underlying the weathered material is likely to be fresh and fractured rock. While stygal communities have been documented in surficial, non-calcrete aquifers and fractured rock aquifers elsewhere in the Yilgarn, they tend to be depauperate (e.g. Bennelongia, 2009, 2011). The richest stygal assemblages in the Yilgarn are in calcretes and, based on available habitat information, few calcrete aquifers appear to be present in the Mine DE and surrounds, and where they are present, such as in the vicinity of MWH001, groundwater is highly saline and therefore not considered very prospective. The most prospective areas for stygofauna in the vicinity of the Project are surficial, fresh or moderately-saline aquifers within and immediately adjacent to the Lefroy palaeochannel to the east and north-east (which is not targeted as part of the Proposal), though there is limited hydrogeological or other habitat information for this area.

Prospectivity for Troglofauna

The primary potential habitat for troglofauna in the Mine DE comprises mineralised zones with well-developed cavities, such as those evident in some drill cores. However, when compared to geologies containing rich troglobitic communities elsewhere in the Yilgarn (e.g. Bennelongia, 2016a) and in the Pilbara (Bennelongia, 2016b), the abundance and size of subterranean spaces in the geologies of the Proposal appear to be limited.

Prior to sampling, it was expected that the abundance and species-diversity of any troglobitic community present would reflect this limitation.

7.3.4 Field Records

Stygofauna

With the exception of a single nematode worm, no stygofauna were collected at the study area. The nematode (Nematoda sp.) was collected from MRC088 (Figure 90) but belongs to a group for which taxonomic and ecological knowledge is extremely limited in a subterranean context. Nematodes are not considered in impact assessments in WA. The results of stygofauna survey indicate an extremely depauperate stygofauna community in the study area.

With the exception of MWH009 (1,970 µS cm^{-1}) all of the bores sampled had hypersaline groundwater at the top of the watertable, further supporting the likelihood of a depauperate community.

Based on the combined results of the desktop review and field survey, it is considered very unlikely that more than a depauperate stygofauna community occurs in the vicinity of the proposed mine pits. Habitat here is primarily limited by great depths to water.

The most prospective habitats for stygofauna in the vicinity of the Proposal are surficial aquifers in palaeochannel deposits to the east and northeast of the mine area in and adjacent to the Lefroy palaeochannel. However, sampling at nine bores in these areas yielded no stygofauna other than one nematode. The status of nematodes as stygofauna cannot be confirmed and they are usually not considered in environmental impact assessments. Sampling also confirmed that aquifers are generally hypersaline, which is a physiological constraint on the occurrence of stygofauna. It is considered that the Proposal is highly unlikely to threaten stygofauna species (Bennelongia, 2020).

Troglofauna

In contrast to expectations of a depauperate community based on desktop information, sampling for troglofauna yielded 110 specimens belonging to 20 species of confirmed and potential troglofaunal. This included one spider (Araneae), one pseudoscorpion (Pseudoscorpiones), three species of centipede (Chilopoda), two species of millipede (Diplopoda), three species of symphylan / 'pseudocentipede' (Symphyla), two species of pauropod (Pauropoda), three species of beetle (Coleoptera), one species of planthopper (Hemiptera: Cixiidae) and four species of isopod (Isopoda) (Table 48). The collection locations of all species are shown in Figure 92. The symphylan ?*Symphylella* sp. BSYM099, both pauropods (Pauropodidae sp. BPU094 and Pauropodidae sp. BPU095), and the pseudoscorpion *Tyrannochthonius* sp. BPS289 were collected in scrape samples only. The beetle *Gracilanillus* sp. BCO193, the isopod *Pseudodiploexochus* sp. BIS396 and the symphylan *Hanseniella* sp. BSYM098 were collected from both scrape and trap samples, whereas the remaining 13 troglofauna species were collected in traps.

Based on morphological characters, most species of troglofauna collected at the Proposal are troglobitic (obligate subterranean). This is further supported by collection depths (based on trap depth) of between 10 - 60 m below the surface. Except for the spider *Oreo* sp. and the pincushion millipede *Lophoturus madecassus*, which represent species that are widespread in WA, all other species are new and have not been recorded outside the area sampled yet.

The trapping period of approximately six months in the first sampling round is likely to have increased trapping success compared to the usual period of 6 - 8 weeks specified by sampling guidelines (EPA, 2016b). However, the relatively small spatial extent of sampling (Figure 90) means that collection records potentially provide a poor guide to the ranges of species. Moreover, in the first round of sampling there was an uneven distribution of holes between impact and reference locations, leading to bias towards collecting troglofauna in the impact areas. The second round of sampling balanced the ratio of impact and reference sampling, although with traps that were not in the ground as long.

Table 48: Species of troglofauna collected at the Proposal (Bennelongia, 2020b)

Higher Classification	Lowest Identification	Impact												Reference												Confirmed minimum linear range
		MDD003	MDD006	MDD007	MDD009	MRC041	MRC045	MRC078	MRC101	MRC112	PTC015	PTC027	PTC028	KJC014	KJC026	KJC032	MRC004	MRC006	MRC023	MRC115	MRC123	MRC126	MRC133	PTC001	PTC024	
Arachnida																										
Araneae																										
Gallieniellidae	*Oreo* sp.															1										Singleton, but probably not true troglofauna
Pseudoscorpiones																										
Chthoniidae	*Tyrannochthonius* sp. BPS289																								1	-
Chilopoda																										
Scolopendrida																										
Cryptopidae	*Cryptops* sp. BSCOL062		1																							**Singleton within impact footprint**
	Cryptops sp. BSCOL063 (*spinipes* sl.)				1													1	1							0.98 km
	Cryptops sp. BSCOL068 (*spinipes* gp)						1									1								1		3.13 km
	Cryptops sp.																	1								Probably juvenile of *C.* sp. BSCOL062
Diplopoda																										
Polyxenida																										
Lophoproctidae	*Lophoturus madecassus*														1											Widespread in WA
Siphonophorida																										
Siphonophoridae	Siphonophoridae sp. BDI066				1													5					1			0.45 km
Symphyla																										
Cephalostigmata																										
Scutigerellidae	*Hanseniella* sp. BSYM096																		1							-
	Hanseniella sp. BSYM098						2															1				0.20 km
	?Symphylella sp. BSYM099							1																		**Singleton within impact footprint**
Pauropoda																										
Tetramerocerata																										
Pauropodidae	Pauropodidae `BPU094`											1														**Singleton within impact footprint**
	Pauropodidae `BPU095`										1															**Singleton within impact footprint**
Insecta																										
Coleoptera																										
Carabidae	*Gracilanillus* sp. BCO193	2																			3					0.94 km
Staphylinidae	Pselaphinae sp. BCO205			4	12	2											1									0.41 km
Family unknown	Coleoptera sp. BCO206									2																**Singleton within impact footprint**
Hemiptera																										
Cixiidae	Cixiidae sp.													1												Singleton
Malacostraca																										
Isopoda																										
Armadillidae	*Pseudodiploexochus* sp. BIS396			4	1	1										30										3.19 km
Philosciidae	Philosciidae sp. BIS371				1	2																				**0.09 km, only within impact footprint**
	Philosciidae sp. BIS372								1											1						1.75 km
Platyarthridae	*Paraplatyarthrus* sp. BIS373		8										3			5								1		3.12 km

Details of each recorded species of troglofauna are provided in Bennelongia (2020b) in Appendix 6.

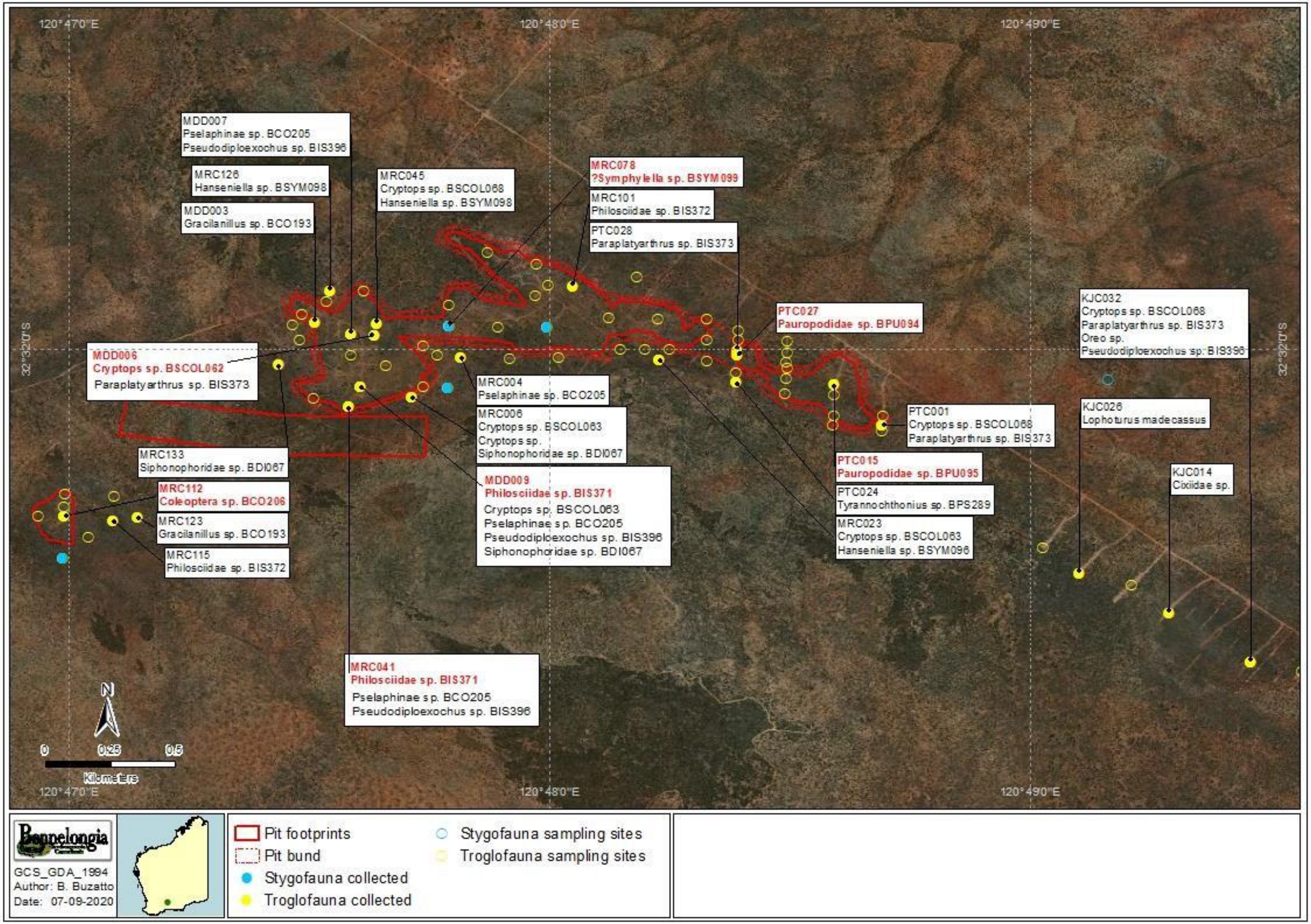


Figure 92: Location of troglofauna records at the Proposal in relation to proposed mine pit footprints

7.3.5 Environmental Values

Subterranean fauna was listed as a Preliminary Key Environmental Factor when the Proposal was referred to the EPA in December 2017, as an assessment of habitat prospectivity had not been completed at that stage. Based on the findings of Bennelongia (2020b), it is unlikely that the areas of impact contain any stygofauna values that require assessment in this ERD.

The field results have identified that troglofauna are present within the mine pits, as 15 species were recorded within the pit boundaries. The troglofauna species and populations that inhabit the habitats that will be intersected by the mine pit are considered an environmental value for this factor.

7.4 Potential Impacts

Table 49 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context.

Table 49: Potential impacts on subterranean fauna

Environmental value	Current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Troglofauna species and populations that inhabit the Proposal mine pits	15 troglofauna species have been recorded to-date within the mine pits Six of these species were recorded only within the mine pits	Excavation of troglofauna habitat within the proposed mine pits	Alteration of habitat characteristics due to mining and seepage from TSF and evaporation ponds	All species are new to science therefore there are no other known impacts from other proposals	Excavation of troglofauna habitat within the proposed mine pits Alteration of habitat characteristics due to mining and seepage from TSF and evaporation ponds

7.5 Assessment of Impacts

The following section assesses the potential direct and indirect impacts on the environmental value identified in Section 7.3.5.

The proposed mine pits are relatively small, ranging from less than 2 ha at Egmont to 31.5 at Fuji / vesuviusand 5.9 ha at Pinatubo, with a total area of excavation of approximately 39.3 ha. Proposed pit depths will be no more than 50 m, but under a precautionary approach troglofauna habitat is assumed to not extend beneath the pits. These mining activities will result in the excavation and removal of troglofauna habitat, based on the findings in Bennelongia (2020b).

The proposed mining may also alter the humidity characteristics of the surrounding and underlying troglofauna habitat. Seepage from the TSF and evaporation ponds is likely to increase the humidity characteristics of the underlying troglofauna habitat and may also flood portions of this habitat close to the water table.

Six of the 20 species of troglofauna recorded at the Proposal are known only from holes that are within the boundaries of the proposed mine pit footprints. There are currently limited collection data with which to confirm the actual distribution of each species, partly due to low capture rates (presumably resulting from low population densities) and the moderate extent of sampling coverage. However, within the survey dataset, the known ranges of some species provide some support for other species also having more extensive ranges than can currently be demonstrated. For example, the isopod Philosciidae sp. BIS371 is only known from holes MDD009 and MRC041, over a linear range of around 80 m within the proposed footprint of Vesuvius pit. However, all four other species collected from MDD009 (*Cryptops* sp. BSCOL063, Siphonotidae sp. BDI066, Pselaphinae sp. BCO205 and *Pseudodiploexochus* sp. BIS396) were also collected from holes outside pit footprints and have linear ranges of up to 3.19 km (Figure 92). This points to the likelihood of Philosciidae sp. BIS371 having a more extensive distribution that can be currently confirmed, including outside proposed mine pits. The caveat to using this kind of surrogate information (using the range of one species as evidence of the range of another) is that the life history (and therefore capacity to disperse) of each species is not known.

The reported ranges of troglofauna species in the Pilbara are generally much larger than the total area of the proposed mine pits (Halse and Pearson, 2014) and it would be expected that ranges as small as the proposed pits would only occur in association with pronounced geological or topographic features. As shown in Figure 91, the continuity of the geological units in each of the proposed mine pits with surrounding undisturbed areas provides support for the notional continuity of key troglofauna habitats.

While ranges may be inferred from the extent of suitable habitat, determining ranges of troglofaunal with confidence is difficult. While the collection of many species from only single bores (e.g. Baehr and Main, 2016), despite extensive sampling, may be due to sampling artefacts, it cannot be ruled out that very small ranges are more common than recognised.

Overall, based on the small proposed extent of mine pits and information gained from the field survey, it is considered unlikely that any of the troglofauna species recorded will have distributions entirely confined to mine pits, although direct support for this conclusion is limited.

Audalia understands that this prediction needs to be verified to ensure that the EPA's objective for this factor can be met. Audalia has therefore commissioned Bennelongia to conduct a third round of trapping of holes within the mine pits and surrounds, in order to demonstrate that troglofauna species are not constrained to the mine pits, TSF or evaporation ponds. This information will be provided to DWER as soon as it is available, and prior to their assessment (expected early 2021).

7.6 Mitigation

Audalia has mitigated the potential impacts to this factor according to the mitigation hierarchy: avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor (refer to Section 11).

7.6.1 Avoid

The following mitigation measures are proposed to ensure that direct and indirect impacts to subterranean fauna are avoided:

1. Mine dewatering will not be conducted; and

2. Groundwater abstraction will not occur within the surficial, fresh or moderately-saline aquifers within and immediately adjacent to the Lefroy Palaeochannel.

7.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to subterranean fauna are minimised:

1. **Limit abstraction within the mine borefield to 0.8 GL/yr in the Key Characteristics Table;**
2. **Ensure the excavation of the proposed mine pits is the minimum required to ensure safe and mining operations**;
3. **Verify that troglofauna species and habitats are not restricted to the mine pits, TSF or Evaporation Ponds.** This is to be verified by conducting troglofauna sampling within additional bore holes. The additional sampling is to better characterise the troglofauna community at all three or four proposed mine pits and in the immediate surrounds and to demonstrate the wider occurrence of species currently only known from the mine pits; and
4. **Design, construct and operate the TSF and Evaporation Ponds in accordance with approvals required under the Mining Act and Part V of the EP Act.**

7.6.3 Rehabilitate

An interim MCP has been prepared to accompany this ERD (Appendix 4) which was developed according to DMIRS Guidelines (2020a; 2020b). The MCP describes the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase including**:**

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks for the mine pit, TSF and evaporation ponds domains; and
- Completion criteria, monitoring and reporting during closure.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to the construction of the Proposal and will be reviewed and revised every three years.

7.7 Predicted Outcome

The EPA's environmental objective for this factor is "protect subterranean fauna so that biological diversity and ecological integrity are maintained."

Audalia has commissioned a third round of troglofauna surveys to verify that troglofauna habitat and populations are not constrained to the mine pits, TSF or evaporation ponds. Once this position is verified then Audalia considers that the EPA's environmental objective for this factor can be met, as the excavation or indirect impact of a relatively small portion of the available habitat would be unlikely to threaten the maintenance of biological diversity and ecological integrity. This information will be provided to DWER as soon as it is available (expected early 2021), and prior to their assessment.

8 TERRESTRIAL ENVIRONMENTAL QUALITY

8.1 EPA Objective

The EPA Objective for this key environmental factor is to maintain the quality of land and soils so that environmental values are protected.

8.2 Policy and Guidance

Relevant EPA guidance documents for hydrological processes are listed below:

- Statement of Environmental Principles, Factors and Objectives (EPA, 2020a).
- Environmental Factor Guideline for Terrestrial Environmental Quality (EPA, 2016l).

Other guidance documents for terrestrial environmental quality are listed below:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Commonwealth of Australia, online resource, 2018);
- Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2020d);
- Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015);
- "Appendix B: Potentially contaminating industries, activities and land uses" in Assessment and management of contaminated sites: Contaminated sites guidelines (Department of Environment Regulation (DER), 2014);
- Global Acid Rock Drainage Guide (International Network for Acid Prevention, 2014);
- Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure (Australian National Committee on Large Dams, 2012);
- Identification and investigation of acid sulphate soils and acidic landscapes (DER, 2015); and
- Erosion and sediment control on unsealed roads. A field guide for erosion and sediment control maintenance practices (NSW Office of Environment and Heritage, 2012).

8.3 Receiving Environment

The section below has been sourced from the following reports, provided in Appendix 7:

- Soil of the Audalia Medcalf Area: Investigations into the soils on which *M. aquilonaris*, *E. rhomboidea* and *S. bremerense* grow - for use in defining critical habitats (Western Horticultural Consulting, 2019);
- Medcalf Project: Geochemical Characterisation of Slurry Samples of Deslimed-Tailings and Gravity-Reject-Tailings and Implications for Tailings Management (Graeme Campbell and Associates (GCA), 2020a);
- Medcalf Project: Characterisation of Mine-Waste Samples from Vesuvius, Fuji, Egmont, and Pinatubo Pits – Implications for Mine-Waste Management (GCA, 2020b);
- Groundwater Supply Investigation. Audalia Resources Limited Medcalf Vanadium Project (GRM, 2020a); and
- Medcalf Project Tailings Storage Facility Design Concept (Golder, 2020).

8.3.1 Survey Effort

Geochemical assessments were completed on both tailings samples and "waste rock" samples to determine the potential for contamination.

Due to the very low strip ratio (ratio of waste rock to ore), there will be no waste rock requiring long term storage in a waste rock landform. All waste rock will be required for construction of embankments or for site closure. The geochemical characterisation work focuses on materials that are located deeper in the soil / geologic profile where samples are obtained from mechanical drill samples.

A soil survey study by Western Horticultural Consulting (2019) focused on identifying the soil characteristics and soil type boundaries associated with *M. aquilonaris*, and provides useful general observations on topsoils and subsoils. These samples were accessed using only hand tools. Additional topsoil characterisation data was acquired by Botanica (2018).

Tailings

Ore will be processed via a beneficiation plant, to upgrade ore to a primary concentrate. The beneficiation process consists of a comminution circuit and gravity separation circuit. The comminution circuit includes a three-stage crushing plant, with no added reagents. The gravity beneficiation circuit includes two stages with concentrate dewatered by thickening and filtration, with the filter cake as the final product for export. The only chemical reagent required for the beneficiation process is the non-toxic flocculant used in the thickening process.

The outcome of the process described above is two types of tailings that will be generated from the beneficiation plant:

- Deslime-fines generated from the comminution circuit by hydrocyclones; and
- Gravity-reject material generated from the gravity circuit.

The two streams will be recombined, thickened, and then pumped through pipelines to the TSF.

Tailings samples were processed by the Nagrom laboratory in Perth. The ore sample used was a composite sample of diamond drill cores collected from a drilling programme in 2015 from the proposed mine pits. Core samples were inspected by Audalia to identify the mineralisation for sample preparation. Perth tap water was used (as a surrogate for desalinated groundwater from site). The process followed by Nagrom was designed to mirror the metallurgical process through the plant. Both solid and liquid samples of deslime-fines and gravity-reject tailings were then couriered from the Nagrom laboratory to GCA laboratory for geochemical testwork.

<u>Mineralogy</u>

Mineralogy on the samples was completed by Townend Mineralogy Laboratory. Assay work was completed by Intertek Genalysis and SGS Environmental.

<u>Multi-element assays and acid/base accounting</u>

Testwork included standard testing and assays for pH and salinity, acid/base accounting for acid forming tendency, multi-element concentrations and water extraction.

Low pH (5) extracts

The tailings solids samples were also subjected to extraction testing at pH 5 using dilute acetic-acid-based solutions. This test provides "a measure of the strength with which elements are chemically bound to the surfaces of the Fe/Al/Ti/Si oxyhydroxides (viz. 'resistates') and kaolinites" in the tailings samples (GCA, 2020a).

Simulated weathering and leaching

In addition, weathering testing at 30 °C was undertaken on 1.00 kg (dry-solids equivalent) of tailings-solids with preparations and processes as described in GCA (2020a). Wetting and drying steps were repeated a few times over the course of about six weeks for the first cycle, and about eight weeks for the second cycle (total of about 14 weeks). The eluted solutes from the weathered tailings were sampled on two occasions, once at six weeks, and again at eight weeks. Throughout the weathered leaching, the tailings-solids were progressively dewatered to near residual-moistures/suctions, and following remoistening with high-purity-deionised-water, allowed to again dewater. The process of alternating cycles of drying and remoistening were completed several times between leachate samplings.

Construction Materials

The mine-waste samples characterisation (GCA, 2020b) was originally commissioned on the basis that a WRL would be required. As project planning proceeded, it became apparent that due to the low ratio of waste rock to ore, that no excess waste rock materials would be realised from mining. Assay work has been completed by GCA (2020b) on the materials consistent with their potential placement in a WRL. However, all mined materials that are not ore, or required for rehabilitation will be used as construction materials for general purpose fill, or the TSF and evaporation pond embankments. Some portions will also be retained for mine closure (capping and erosion protection). Hence, all materials that would otherwise be referred to as waste rock, are referred to as 'Construction Materials' in this ERD.

In early 2019, a set of 26 samples was selected for testing following a review of the percentage-sulfur data from the whole deposit, and other assays, for 1 m intervals in the Proposal's geological database. Sample selection reflected the indicative pit-shells at that time. The selected samples for testing typically correspond to 3 m composites (i.e. three successive 1 m intervals composited).

In light of refinements to the design of the pit-shells during 2019, eight of the 3 m composites initially selected were no longer relevant for testing. Although earlier pit-shells were projected to produce minor amounts of the Basalt (BAS) unit from the Fresh-Waste-Zone, subsequent pit-optimisations show that mining will not occur within the Fresh-Waste-Zone of any of the pits. With the pit-shell revisions, the results presented and discussed in this study correspond to 18 samples (as 3 m composites).

In addition, four samples of Fresh-Zone-Basalt from the Vesuvius Pit, and one Fresh-Zone-Basalt sample from neat the Pinatubo Pit, were tested as 'model-samples' of the Fresh-Zone-Basalt to be produced from the borrow-pit for TSF construction. These five samples were also 3 m composites.

The locations of the drillholes employed for sampling, together with pit-area geology, are shown on Figure 93. Though some drillholes are located outside the pit-footprints, the geologic profiles sampled from these drillholes are representative of the Mottled-Zone and Saprolite-Zone making-up the waste-zones of both Pits.

Mineralogy on the construction samples was completed by CSIRO (2019). Assay work was completed by Intertek Genalysis and SGS Environmental.

Testwork included standard assays for pH and salinity, acid/base accounting for acid-forming tendency, multi-element concentrations and water extraction testwork. Water-Extraction Testwork was based on slurries prepared from the 'coarse-crushed' (nominal -5 mm) samples prepared using high-purity-deionised-water (HPDW), and a solid : water ratio of 1:2 (w/w). Test-slurries bottle-rolled overnight and then left to 'still-stand' for ca. 1-2 days prior to decanting supernatants for vacuum-filtration (0.45 µm-membrane) for analysis.

Saturated-Leaching Columns contained 1.00 kg (dry-solids equivalent) of 'coarse-crushings' (-5 mm nominal), and were leached with 0.50 kg lots of HPDW. It generally took 1 - 2 weeks for each lot of HPDW to drain through the columns. All samples produced around 0.20 kg of leachate for Cycle-1, and then about 0.50 kg thereafter.

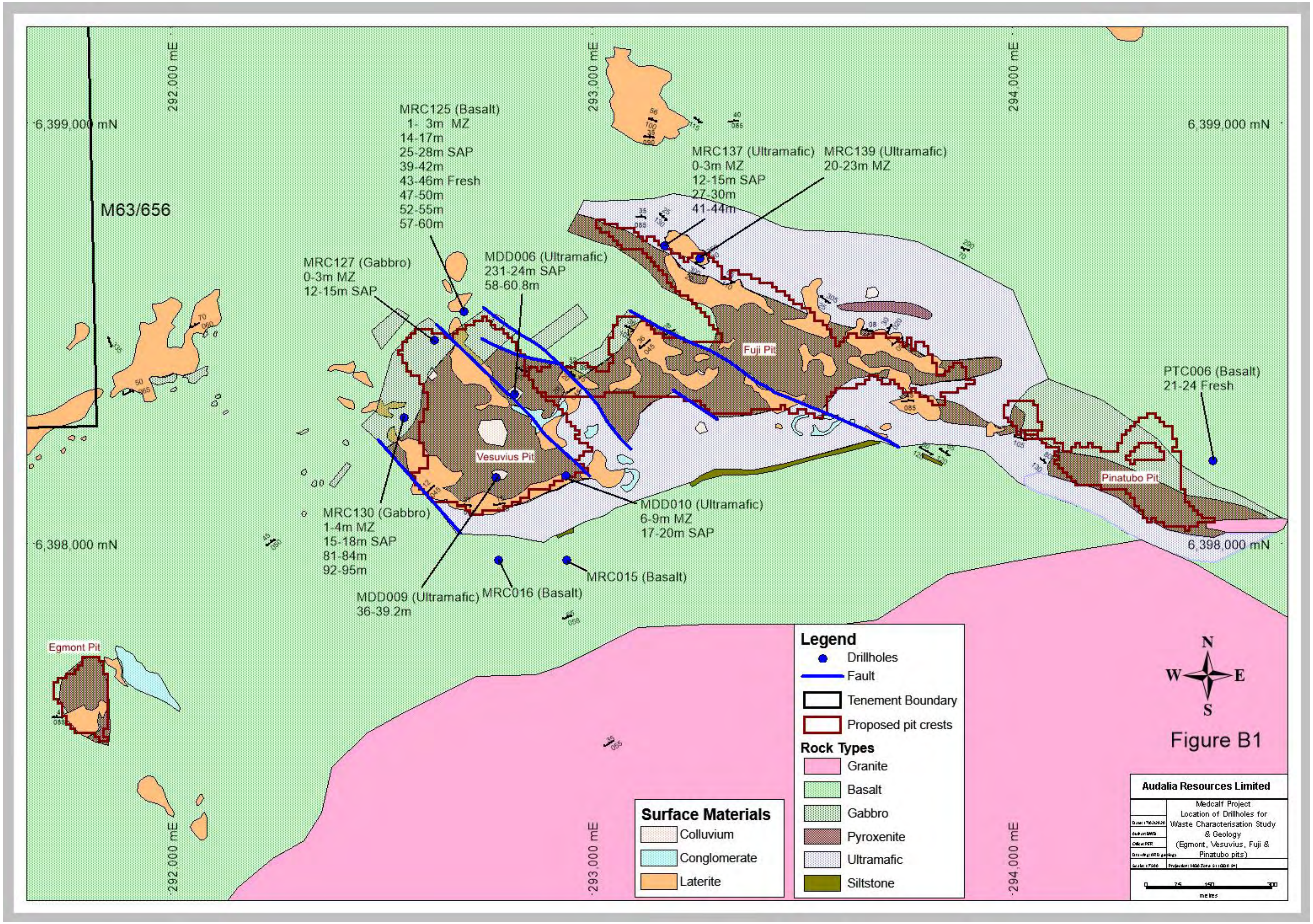


Figure 93: Sample locations and geology map

Soils

Soil investigations focused on topsoil and subsoil (i.e. notionally the top 1 m of soil profile) were conducted in April and August 2019 by Western Horticultural Consulting (2019) to determine the range of soil types on which *M. aquilonaris* grow. Of interest also, was any observations regarding the soils upon which *Eucalyptus rhomboidea* and *Stenanthemum bremerense* grow.

The soils, landform type and vegetation were described at 74 sites (Figure 93). Sites were chosen to sample the full range of soils present across all populations and landscape types. Hand tools (spade, pick and hand auger) were used to minimise disturbance risks to *M. aquilonaris*.

The depth of each soil horizon, soil texture (hand assessment), soil structure, colour, percentage of coarse fragments including gravel (field sieving), field pH and electrical conductivity were recorded. The soil profiles were described using the terminology of McDonald et al (1990). Soil colours were described according to standard Munsell colour chart notation. Estimates of plant available water of representative sites were calculated based on soil texture, percentage of coarse fragments and estimated rooting depth.

Eighty-one soil samples of the different soil horizons from 38 sites that represented the range of soil groups encountered in the soil survey were sent to the Chemistry Centre for physical and chemical analysis. These samples were analysed for:

- Percentage of stones;
- pH water;
- pH CaCl; and
- EC.

A subset of samples from each soil group were submitted to a more comprehensive suite of analysis:

- Exchangeable Sodium Percentage (ESP);
- Base Saturation Percentage (BSP);
- Ca, K, N, Mg and Na;
- Cation exchange capacity (CEC);
- Organic carbon;
- % of clay, silt and sand; and
- Mehlich suite (Al, P, K, Ca, Na, Mg, B, S, Cu, Fe, Mn, Mo, Cd, Ni, Pb, Zn, Se).

8.3.2 GEOLOGY

Butler (2020a) reviewed the regional geological structure, regional mineralisation, and Medcalf deposit mineralisation. The Butler (2020a) report is included as Appendix 7.3.

The Medcalf deposit was discovered by Union Laporte Miniere in the 1960s. Historic exploration in the 1970s and 1980s by Amoco defined three separate areas of vanadium mineralisation known as the Vesuvius, Fuji and Egmont Prospects. The mineralisation is contained within a pyroxenite sill and was drilled during 2013 by Audalia for resource definition. The latest JORC (2012) Resource of 32 Mt @ 0.47% V_2O_5, 8.98% TiO_2 and 49.2% Fe_2O_3 was announced to the market on August 31st, 2018. The Proposal resource is thus relatively small, and the resource geology is understood to a fine resolution.

The Proposal lies in the Archaean aged Lake Johnston greenstone belt in the Yilgarn Craton. This belt contains komatiite lava flows, subvolcanic intrusions, mafic volcanic rocks, felsic volcanic rocks, banded iron formation (BIF) and sedimentary rocks. The bedrock geology is generally masked by lateritic duricrust, deep oxidation and transported material. Regolith and weathered bedrock thickness is usually 60 to 80 m. Intense weathering of ultramafic rock types has resulted in widespread development of silica-rich "cap-rock" in the saprolite zone (often referred to as laterite or limonite). The fully developed lateritic weathering profile is divisible into four zones. Starting from the top, they are lateritic residuum, mottled zone, saprolite and saprock.

The ore deposit is hosted by the Medcalf layered sill, which is a flat-lying igneous body which has intruded parallel to the enclosing basalts. The sill is comprised of an upper gabbroic zone, a middle pyroxenite zone, and a lower amphibolite zone (Butler, 2020a). The geology of the Medcalf sill is relatively simple and not analogous to gold deposits in the Yilgarn that may have large variability (lithological and alteration) in their width, direction and shape. It is more analogous to the iron ore deposits of the Pilbara, i.e. long (several kilometres) tabular flat deposits that are exposed at the surface (Figure 94, Figure 95 and Figure 96) (Butler, 2020b). Project geology has been investigated at a detailed level by Butler (2020b). The Butler (2020b) report is included as Appendix 7.6.

Mineralogy

Three separate zones of vanadium, titanium and iron mineralisation have been identified within the Mine DE - named the Egmont, Vesuvius / Fuji and Pinatubo prospects. The three major rock types within the proposed pits (Figure 96) are:

- Gabbro (dark green);
- Pyroxenite (red); and
- Ultramafic (purple).

Vanadium, iron and titanium have been concentrated in a pyroxenite unit in the Medcalf deposit. Pyroxenite, which is the ore to be mined and processed, is the dominant rock type within the pits. In the mineralised area the magnetite-rich sequence is deeply weathered, with 60+ m of saprolite showing vertical zonation of weathering minerals due to progressive weathering. Further enrichment of these metals has occurred through weathering and regolith formation, and almost all the vanadium and titanium mineralisation lies in the saprolitic zone.

The target ore within the pit shell is almost entirely weathered, with the weathered zone extending beyond the pit floor (approximately 50 m deep) (Figure 97). No fresh rock will be mined from within the pit. All ore and waste is being mined from above the water table.

The pyroxenite host rock of the Medcalf sill often outcrops, including at the Proposal prospects. Very little waste material is therefore present within the pit shell, being gabbro, ultramafic and sub-grade pyroxenite (which resides within the cover material (Figure 97). The majority of the waste lies near the surface and is generated through stripping the hanging wall to access the deeper ore (Figure 96) (Butler, 2020b).

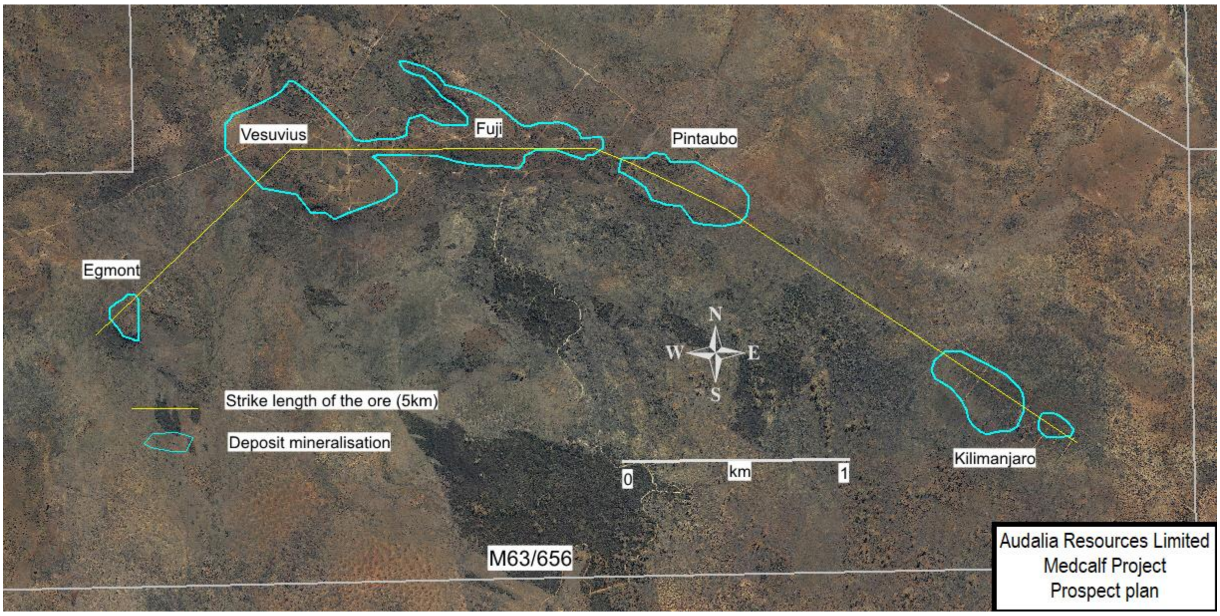


Figure 94: Prospect Plan showing Continuous Mineralisation over 5 km of strike

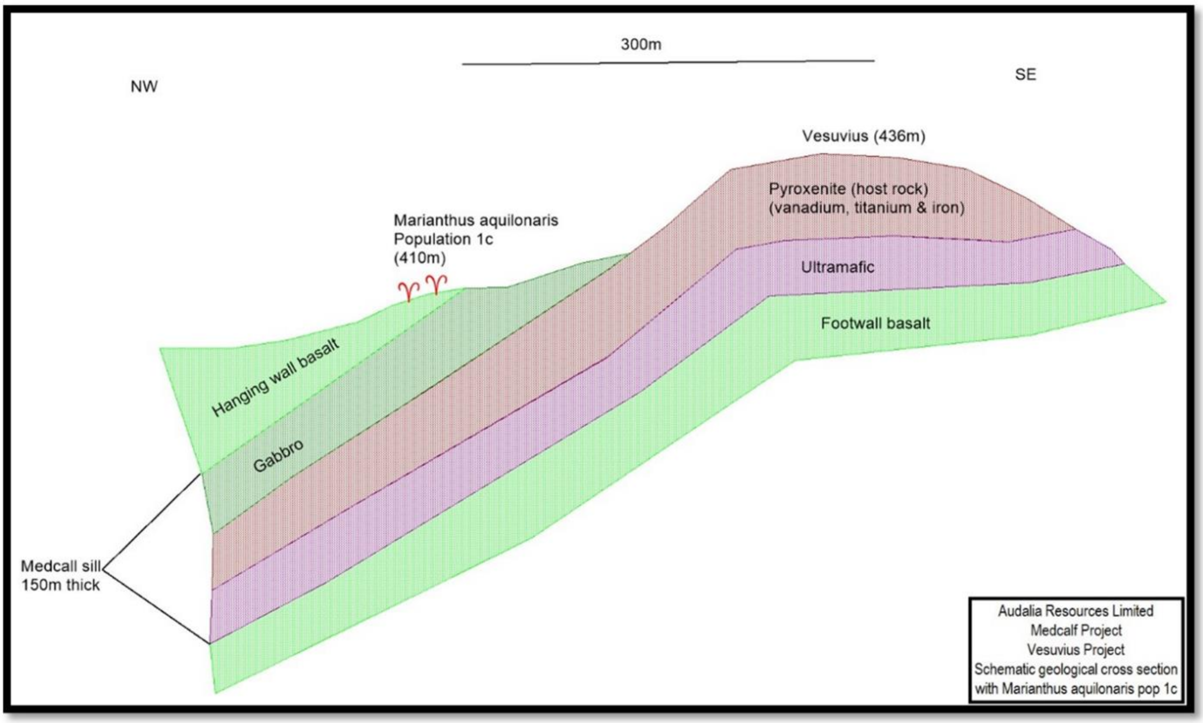


Figure 95: Schematic cross section of the Medcalf Sill

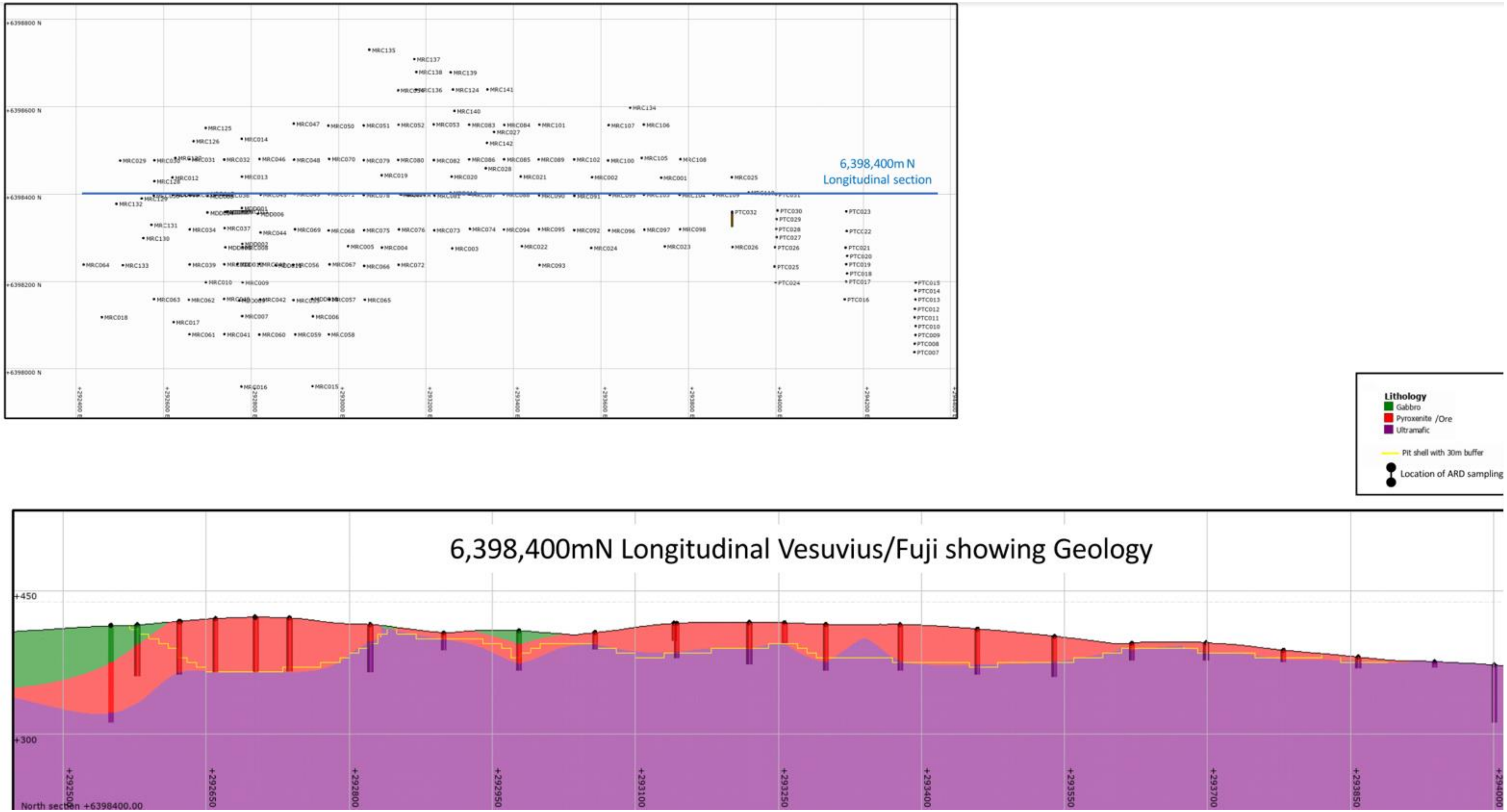


Figure 96: Long section through the Vesuvius/Fuji Deposits showing Continuous Lateral and Vertical Extent of the Ore

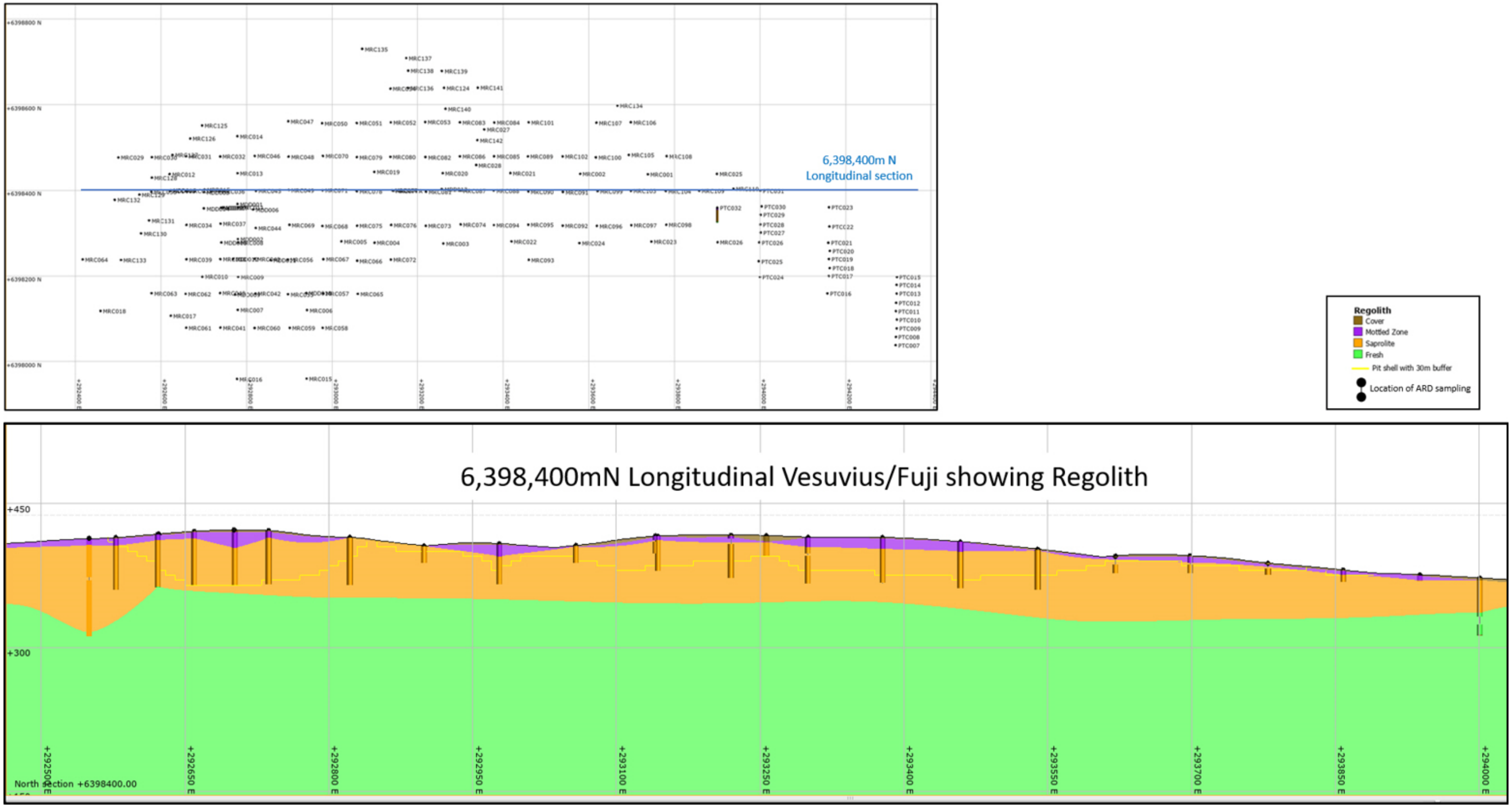


Figure 97: Long section through the Vesuvius/Fuji Deposits showing Continuous Lateral and Vertical Extent of the Regolith

Mineralogy of the vanadium rich zone is dominated by hematite-goethite and kaolinite with minor ilmenite, diaspore, gibbsite, anatase, rutile, magnetite, quartz and mica. Table 50 details the mineral abundance recorded for Medcalf ore.

Table 50: Mineralogy of Medcalf Ore (from Audalia, 2018)

Mineral	Abundance %	Mineral	Abundance %	Mineral	Abundance %
Magnetite-mahemite-hemite (Ti-hemite)	40.845	Muscovite	0.006	Psilomelane	0.023
Limonite	22.953	Biotite	0.002	Siderite	0.036
Ilmenite-alteration ilmenite	15.823	Kyanite	0.002		0.003
Leucoxene	0.221	Phenakite	0.001	Pyrrhotite	0.001
Rutile	0.008	Greenalite	0.050	Chalcopyrite	0.002
Kaolinite	18.240	Amesite	0.255	Sphalerite	0.001
Monmorillonite	0.191	Diopside	0.001	Alunite	0.026
Pyrophyllite	0.124	Hornblende	0.004	Gibbsite	0.042
Illite	0.300	Almandine	0.008	Others	0.578
Talc	0.003	Fluorite	0.002	**Total**	**100.000**
Quartz	0.223	Calcite	0.001		
Feldspar	0.023	Dolomite	0.002		

8.3.3 Materials Characterisation

Soils

This section has been sourced from Western Horticultural Consulting (2019) unless stated otherwise.

The upper surface of the rocks in the Mine DE has undergone laterisation. The lateritic profile can be seen at the top of the Proposal landscape. The soil profiles are noted to be generally a gravelly sandy loam overlying ferricrete (duricrust) and lateritic boulders. Beneath the ferricrete layer is the mottled zone, which in turn overlies saprolite and then sap rock. The parent material is mafic rock which results in a darker red, loamier topsoil in other locations.

The lateritic material and the underlying mafic rock provide the parent material for the soils. The extent of dissection of the lateritic profile has a large influence on what soils are formed. The soil types are noted to generally follow a sequence down the slope (catena) with:

- Gravelly lateritic soils developing over ferricrete or ironstone boulders at the top of the landscape;
- Below the breakaway face shallow gravelly soils develop over the mottled zone;
- Where the underlying mafic rocks have been exposed on the upper and mid slopes these rocks generally weather to form loam over clay (duplex) soils;
- Deeper loamy surfaced duplex soils develop as a result of colluvial movement on the mid and lower slopes; and
- Salt lakes that occur at the bottom of the landscape.

The topsoil materials within the mining area are noted to be generally sandy loams, non-saline, not sodic, with moderate to high levels of organic carbon. The only subsoil found to be saline was the 'Alkaline red shallow loamy duplex' soil, which was found near the valley floor, well away from the area to be mined.

Seventy-four soil profiles were sampled in the survey area. Additional observations sites of the surface soil texture and vegetation type were also made at locations outside the Mine DE to gain an understanding of the regional distribution of the soils. The soil types can be broken down into five main groups which are outlined in Table 51.

Table 51: Major soil groups of the Medcalf study area

Soil Types of the Study Area		
Soil Type	**Location in the landscape**	**Soil Description**
Alkaline red shallow loamy duplex	Major soil group within the Mine DE and surrounding areas. It occurs below the gravelly lateritic plateau and extends towards the valley floor. The soil surface contains a scree of dark lateritic gravels, particularly on the upper slopes where they may cover 70% of the soil surface.	Contains a range of red, loamy duplex soils with the soil properties at each site being influenced by the geology of the parent material and its position in the landscape. The topsoil is 10 - 15 cm of dark reddish-brown sandy loam. A dark brown/ red clay sub soil occurs within 40 cm of the soil surface. The soil has a sub angular blocky structure. Contains 0 - 60 % dark angular iron stone gravel and rocks. The topsoil is neutral to alkaline pH (pHwater = 7 – 8.5). The subsoil is alkaline (pHwater = 8.5 – 9). The salinity of the soil is low except when this soil group occurs lower in the landscape where the subsoil is affected by the saline regional water table.
Loamy gravel	Major soil group within the Mine DE and surrounding areas. It occurs on the lateritic plateau at the top of the landscape, and on the upper, mid and lower slopes. The soil surface contains a scree of dark lateritic gravels that may cover 70% of the soils surface. Ironstone rocks occur on the soil surface, particularly on the upper slopes.	Topsoil is generally about 10 - 15 cm thick and is a dark reddish brown, gravelly loamy sand to sandy loam. The surface horizon grades into a dark reddish brown sandy loam to sandy clay loam which extends to depths of greater than 50 - 80 cm. Percentage of gravel generally increases from 20 - 50 % in the topsoil to 60% in the subsoil. Clay layer may be encountered at depth. pH is close to neutral. Soil is not saline.
Shallow gravel over indurated mottled zone	Minor soil group within and surrounding the Mine DE. Occurs in the upper slopes below the lateritic plateau. Usually found on ridges that are often only one or two meters higher than the surrounding areas. 70 – 90 % of the soil surface is covered with a scree of dark lateritic gravels and fragments of limonite rock.	Topsoil is generally about 10 - 15 cm thick and is a dark reddish brown sandy loam. In most examples the dense, indurated mottled zone occurs directly below the topsoil (at less than 15 cm deep). In some cases, a sandy clay loam subsoil layer can occur below the topsoil, with the indurated mottled zone occurring at depths of no greater than 30 cm. The soil contains between 10 and 50% dark angular ironstone gravel.

Soil Types of the Study Area		
Soil Type	**Location in the landscape**	**Soil Description**
		Topsoils and subsoils are generally acid, with a pHwater between 4.5 and 7. The salinity of this soil is generally low
Stony soils	Minor soil group within and surrounding the Mine DE. Usually occurs higher in the landscape Soil surface contains rocks that may cover up to 90% of the soils surface. The bedrock may outcrop in places.	Topsoil is generally about 10 - 25 cm thick and is a dark reddish brown, rocky loamy sand to sandy loam. The percentage of gravels and rocks in the topsoil can be as high as 90%. This topsoil overlays bedrock. The pH is close to neutral (pHwater = 7 - 7.5) This soil is not saline.
Shallow gravel	Minor soil group within and surrounding the Mine DE. Soil is often found at the top of the landscape adjacent to the breakaway face. Soil surface contains a scree of dark lateritic gravels and rocks that may cover up to 90 % of the soils surface Ironstone cap rock (ferricrete) may outcrop in places.	The topsoil is generally about 10 - 25 cm thick and is a dark reddish brown, gravelly loamy sand to sandy loam. The percentage of gravels and rocks in the soil can be as high as 90%. This topsoil overlays ironstone boulders or lateritic cap rock. The pH is close to neutral (pHwater = 7 - 7.5). This soil is not saline.

Percentage of stones (>2 mm)

All soils generally contained a high percentage of gravels. The percentage of gravels was typically between 20 and 50% in the topsoils, with some soils containing up to 80% gravel.

pH

The 'Alkaline red shallow loamy duplex' soils typically had neutral pH's in the topsoil and were strongly alkaline in the subsoil with the pH_{CaCl} ranging from 7.2 - 8.6. The 'Loamy gravel' and 'Shallow gravel' soils had pH's that were close to neutral (the pH_{CaCl} ranged from 5.9 - 7.7).

The 'Shallow gravel over indurated lateritic zone' soil is typically acidic. The pH_{CaCl} of this soil ranged from 3.8 - 6.3. Many of the samples had a pH_{CaCl} of less than 4.5.

Electrical Conductivity

Electrical conductivity is a measure of the salinity of the soil. The laboratory analysis showed that three of the sites contained soil that had a high salinity.

One of these sites was a 'Shallow gravel over indurated lateritic zone' soil. This site was located immediately below a small breakaway and the site notes indicated that this area was bare of vegetation. The other two sites were 'Alkaline red loamy shallow duplex' soils which were located away from the mining area, lower in the landscape near a drainage line. It is likely that the regional saline groundwater table was influencing the soil salinity in the subsoil at these locations.

Organic Carbon

The topsoil of all soil groups contained moderate to high levels of organic carbon (1.2 - 2.8 %).

Percentage of Clay, Silt and Sand

The particle size analysis conducted by the laboratory agreed well with the textures described in the field during the soil survey. The topsoil of all soil groups contained a similar percentage of each particle size fraction and generally had sandy loam textures.

Exchangeable Sodium Percentage

Sodic soils are prone to dispersion and soil structural issues which can reduce water infiltration and root penetration. A soil with an ESP of greater than 15 is regarded as sodic.

None of the topsoils of any of the soil types that were analysed were sodic. The only sample that was sodic was from the indurated mottled zone (sample 10 C which had an ESP of 23.8).

Acid Sulphate Soils

The Proposal is not located within Class I or Class II areas as per the Australian Soil Resource Information System (ASRIS) Acid Sulphate Soils (ASS) mapping.

Waste Rock

Due to the low strip ratio of the pit, no waste rock dump is required. All waste rock will be utilised in construction (reducing the need to excavate for construction materials) or be backfilled into the borrow pit.

Waste materials will be mined from three regolith horizons – cover, oxide and transitional – and are comprised of three rock types: gabbro, pyroxenite and (ultramafic) amphibolite. The weathered zone extends beyond the pit floor - no fresh rock will be mined from within the pit. GCA (2020b) assessed waste rock geochemical characteristics.

Following a review of the %S, and other assays for 1 m intervals in the Proposal's geological database, 26 samples were selected for testing by GCA (2020b). The samples selected reflected the indicative pit shells as at 2019, GCA (2020b) typically composited three successive 1 m interval samples to form one sample for geochemical characterisation. The individual 1 m interval samples from which the GCA (2020b) samples were composited are presented in Table B1 of the GCA (2020b) waste rock characterisation report included as Appendix 7.2.

A map of the GCA (2020b) composite sample locations and depths is provided in Figure 98. Given the small scale of operation, detailed knowledge of the orebody, the consistently low sulphur concentrations, mineralogy of the deposit and significant number of samples assayed in the geological database, the sampling is considered adequate to characterise the materials.

As the pit shell design was further refined, eight of the 3 m composites initially selected were no longer relevant for testing. GCA (2020b) therefore results presented and discussed geochemical characteristics of 18 composite samples from within the pit shells. The composite waste rock samples analysed by GCA (2020b) included four samples of basalt from the Vesuvius Pit, and one basalt sample from near the Pinatubo Pit. These samples were tested for characterisation of the fresh zone basalt to be taken from the borrow pit for TSF construction. Although some drillholes sampled for waste characterisation were located outside the pit footprints, the geologic profiles sampled from these drillholes are representative of the mottled zone and saprolite zone making up the pit waste zones (GCA, 2020b).

Gabbro

The gabbro is a mafic intrusive greenish grey rock that has a grain size of 2 - 5mm and ranges from massive to moderately foliated. In the mottled and lateritic residuum zones the gabbro's plagioclase and tremolite are replaced by a textureless limonitic clay (Butler, 2020b).

Audalia has mapped gabbro outside the known extent of the Medcalf Sill, extending from Egmont through Vesuvius and Fuji to Kilimanjaro. These gabbro outcrops are currently regarded as faulted or folded extensions (Butler, 2020b).

Gabbro is located in the hanging wall of the Vesuvius, Pinatubo and Fuji pits. The Egmont pit does not contain gabbro. The gabbro accounts for 25% of the waste volume. The composition of the gabbro is very consistent over the deposits, with the two main regolith types being the mottled zone and the saprolite zone.

Drillhole MRC127 (Figure 98) was sampled for the GCA (2020b) waste rock characterisation study (i.e. gabbro mottled zone from interval 0 - 3m depth). Geological logging of the mottled zone of the Vesuvius gabbro and the Pinatubo gabbro mirrors each other.

Drillhole MRC130 was sampled from gabbro adjacent and to the northwest of the Vesuvius prospect for the GCA (2020b) characterisation the gabbro saprolite zone from 15 - 18 m depth. Geological logging of the saprolite zone of the Vesuvius gabbro and the Pinatubo gabbro mirrors each other.

In the context of Audalia's understanding of the relatively straightforward Medcalf deposit geology, the samples collected from the two Vesuvius drillholes MRC127 and MRC130 are sufficient for physical and geochemical characterisation of the mottled zone and saprolite gabbro. It was determined that the gabbro:

- Lies at shallow depths (0 - ≈ 20 m);
- Is oxidised; and
- Contains no sulphides.

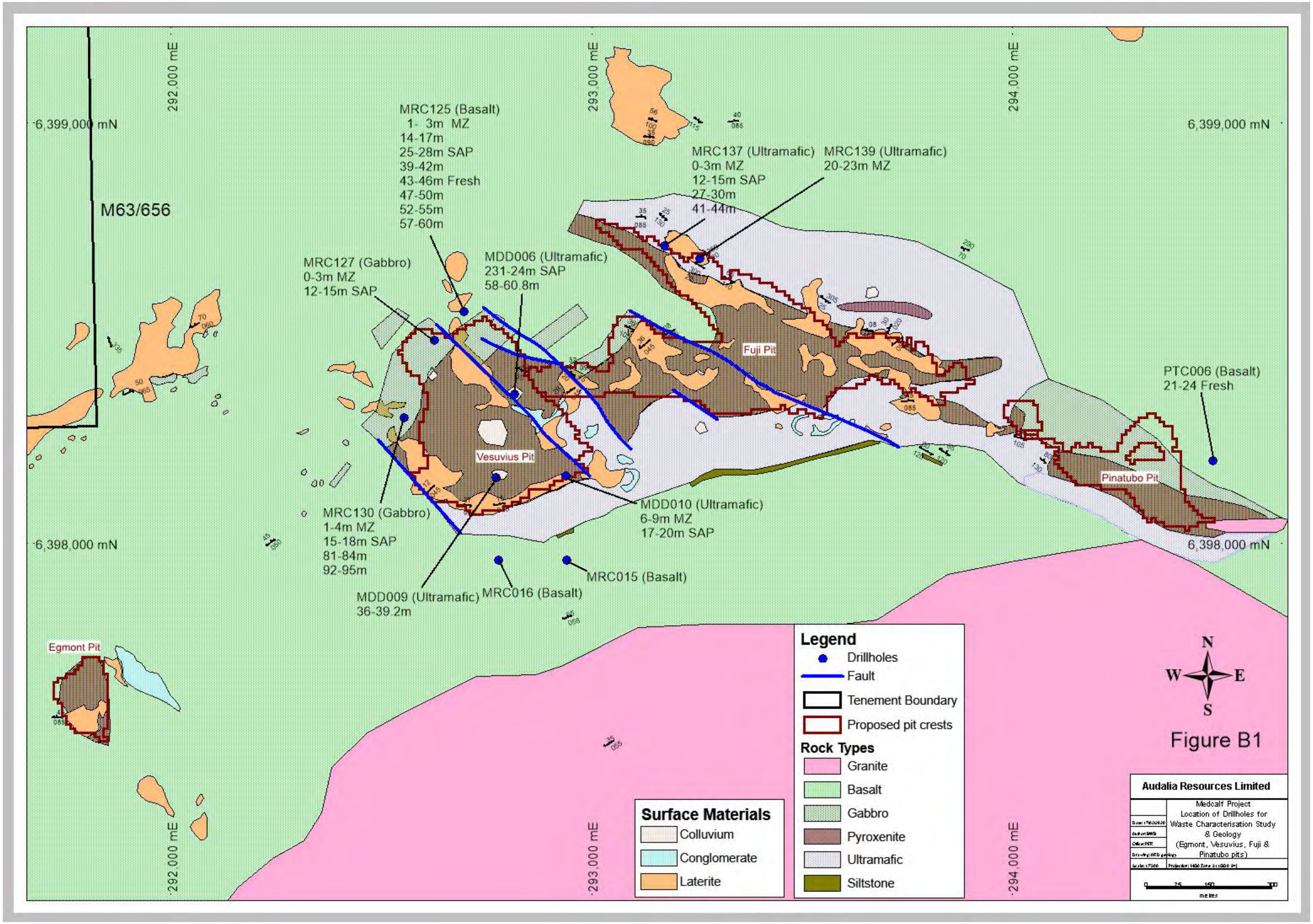


Figure 98: Map of GCA (2020b) Composite Waste Rock Geochemistry Samples

Ultramafic

The ultramafic zone is variously represented by talcose tremolite chlorite schist, medium-grained tremolite rock and pale orange jasper. Talc is stable through the weathering profile and can still be identified in iron-rich or clay-rich material otherwise lacking diagnostic features. The ultramafic zone consists of brown to pale grey-green clay with subordinate orange chert. Relic textures in the grey green clay were restricted to disseminated 1 to 10%, 0.5 mm black opaques. The orange chert is a weathering product and forms thin veinlets in saprolitic ultramafic. The chert contains disseminated 0.5 mm black opaques similar to those in surrounding saprolite.

The ultramafic zone is mainly located in the pit footwalls, and accounts for 30% of the total waste volume. The composition of the ultramafic zone is very consistent over the deposits, with mottled zone and saprolite zone being the two main regolith types.

Drillhole MRC137 was sampled (Figure 98) as part of the GCA (2020b) work with the following samples collected for testing: ultramafic cover zone (0 - 1 m), mottled zone (1 - 3 m) and saprolite zone (12 - 15 m), (27 - 30 m) and (41 - 44 m).

Geological logging of the saprolite zone of the Fuji ultramafic and the Pinatubo ultramafic mirrors each other. This saprolite zone extends across to Egmont as well.

The two Vesuvius drillholes MDDD006 and MDD009 and the two Fuji drillholes MRC137 and MRC139 provide are physically and geochemically representative of the gabbro and ultramafic zones. In summary, the ultramafic:

- Lies at mostly at the base of the pit (footwall);
- Is oxidised; and
- contains no sulphides.

Pyroxenite (below cut-off grade) – Cover (Construction material)

The pyroxenite is a coarse-grained 2 - 5 mm tremolite igneous rock with black opaques. The pyroxenite contains the mineralisation of vanadium, titanium and iron and the mineralisation varies across the deposits.

The cut-off grade for pyroxenite is 25.7% iron content. Pyroxenite with iron content below the cut-off grade reports as mineralised waste. The pyroxenite cover waste accounts for 85% of the total pyroxenite waste volume and is exposed at the surface on topographic highs as laterite zones and conglomerates. This material is heavily leached and blocky, making it well suited to use as a construction material (i.e. competent and benign). Geochemical analysis results for Pyroxenite Cover Sample MDD013 are listed in Table 52. Of particular relevance to the proposed use as construction material are the low sulphur and phosphorus concentrations.

Table 52: Geochemical Analysis results for Pyroxenite Cover Sample MDD013 (0 – 1 m depth)

TiO_2	V_2O_5	Fe_2O_3	SiO_2	Al_2O_3	MnO	CaO	P	S
3.41	0.38	53.07	17.83	15.59	0.09	0.06	0.01	0.06
MgO	**K_2O**	**Na_2O**	**Zn**	**Cu**	**Cr_2O_3**	**Ni**	**Cl**	**Co**
0.14	0.02	0.22	0.01	0.02	0.11	0.01	0.19	<0.005

The same blocky material occurs at depth in the saprolite zone where MRC130 was sampled for waste rock characterisation at a depth of 92 - 95 m.

The physical and geochemical characteristics of the pyroxenite waste, comprised mostly of cover material, are well understood. In summary, the pyroxenite waste:

- Lies at surface on topographic highs;
- Is heavily leached over billions of years to leave residual iron;
- Contains negligible, if any, sulphides; and
- Is physically competent and geochemically benign.

Tailings

The Medcalf ore is somewhat unique in being oxidised and non-sulphide bearing (non-acid forming) and therefore non-magnetic making the conventional processing route not suitable to this orebody (Butler, 2020b).

Comminution and beneficiation of the ore will produce a concentrate stream (product) and a tailings slurry, which will be piped to the TSF for disposal. GCA (2020a) analysed the geochemistry of two tailings slurry samples:

- Deslimed Tailings (D-Tailings)
    - Bulk Cyclone OF; and
- Gravity Reject Tailings (GR-Tailings)
    - CUF P100 0.5mm Bulk RC100 OF.

GCA (2020a; Appendix 7.1) reported that, geochemically, the D-Tailings and GR-Tailings samples are essentially identical, reflecting physical (i.e. sizing / density-based) fractionation and differentiation when beneficiating the ore blends.

<u>Tailings Solids</u>

Both tailings solids samples were mostly comprised of hematite, goethite, and kaolin, with subordinate anatase, rutile, and quartz. The GR-Tailings solids sample also contained halloysite as a minor component (GCA, 2020a).

Cr(II)-reducible S concentrations were below the detection-limit of 0.005 % for both the D-Tailings and GR-Tailings solids samples, with both samples classified as Non-Acid Forming (NAF) by GCA (2020a).

Each tailings solids sample was characterised by major / minor-element concentrations below, or comparable with, those typically recorded for soils, regoliths and bedrocks derived from non-mineralised terrain. Although each tailings solids sample was enriched in Cu, Ag, Bi, and V, the degree of enrichment was not of concern in a geochemical context (GCA, 2020a). The element enrichments reported fall within ranges recorded for strongly ferruginous tailings solids produced at hard rock mines for a wide range of commodities throughout the WA mining industry (GCA, 2020a).

The D-Tailings and GR-Tailings solids samples were subjected to extraction testing at pH 5 (using dilute acetic acid solutions) to measure the strength with which elements are chemically bound to Fe/Al/Ti/Si oxyhydroxide and kaolinite surfaces. Despite the mildly acidic conditions, the concentrations of elements in the pH extracts were typically below detection limits (1 µg/L) or within the range 10 – 100 µg/L. The similarity of elemental extraction from the tailings solids at 'process' and elevated acidities indicates that elements are bound relatively strongly to sesquioxide surfaces (i.e. predominance of strong 'inner-sphere' complexes of the high-affinity / poorly-reversible type involving surface hydroxyl groups). It is implicit that elements incorporated into the crystal structures of the various 'resistate minerals' are totally 'fixed' geochemically (GCA, 2020a).

The more weakly bound elements assayed (those with concentrations within the range 10 - 100 µg/L), such as Cu, Ni, Zn, and Co, would be characterised by potentially leachable pools within the sub-mg/kg (dry-solids basis) range only. Exceptions to the above were:

- Mn with pH 5-extract concentrations of 200-720 µg/L; and
- B with pH 5-extract concentrations of 160-220 µg/L

The pH5-extract Mn concentrations reflect the weaker interaction of Mn(II) forms with oxyhydroxide surfaces. The pool size for such weakly bound Mn forms is within the 1 - 10 mg/kg (dry-solids basis), and thus modest. The elevated pH5-extract B concentrations were a function of the B concentration of the pH5-Feed solution, which was 89 µg/L (GCA, 2020a).

<u>Tailings Slurry Waters</u>

The slurry waters for the D-Tailings and GR-Tailings samples were neutral, and of potable salinity' reflective of both a low salt content of the ore blends, and the use of Perth tap water in the metallurgical testwork program (in place of the desalinated water to be used in ore processing).

The concentrations of a wide range of minor elements were typically below, or close to, the respective detection limits (1 µg/L). Several elements that were enriched in the corresponding tailings solids (Cu, Ag, Bi, and V) exhibited low solubilities in the tailings slurry waters. Notable tailings slurry water elemental enrichment included D-Tailings V (78 µg/L) and GR-Tailings Mn (420 µg/L). Both tailings slurry water samples had NO_3-N concentrations of 5-6 mg/L (GCA, 2020a).

8.3.4 Environmental Values

The information provided in Sections 8.3.1 – 8.3.3 was utilised to determine the environmental values that require assessment for this factor. Values were included for assessment based on the definition of Environmental Values relevant to Terrestrial Environmental Quality (from the EPA's Environmental Factor Guideline; Terrestrial Environmental Quality):

Environmental value is defined under the EP Act as a beneficial use, or an ecosystem health condition.

The beneficial uses of good quality land and soil are primarily agriculture, maintaining drinking water quality, recreation and cultural values. Ecosystem health values that are supported by land and soils include biodiversity, water quality, and seed banks.

The following environmental value was therefore determined to require assessment for this factor:

- The ecosystem health values that the soils within the DEs support, including biodiversity and seed banks.

8.4 POTENTIAL IMPACTS

The following issues are noted in the EPA's Environmental Factor Guideline; Terrestrial Environmental Quality, as being commonly encountered by the EPA in their assessment of proposals:

1. Land use practices causing erosion impacts to soil quality;
2. Land use practices causing salinity impacts to soil quality;
3. ASS;
4. Agricultural practices causing impacts to soil structure and quality; and
5. Waste structures, including TSFs.

Table 53 defines the potential impacts (direct, indirect and cumulative) on the environmental value for this factor in a local and regional context.

Table 53: Potential Impacts to Terrestrial Environmental Quality

Environmental value	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
The ecosystem health values that the soils within the DEs support, including biodiversity and seed banks	Discharge of up to 45 kL/day of treated sewage via irrigation Disposal of putrescible waste at the landfill	Contamination of soil from seepage from the TSF or spillage of tailings Hydrocarbon spills causing contamination Seepage, leaks or spills of saline water or desalination brine Erosion from active or rehabilitated structures spreads sediment into terrestrial environment Disturbance of ASS	No other proposals are located in proximity to the Proposal	Direct impacts from waste disposal and potential indirect impacts

8.5 ASSESSMENT OF IMPACTS

8.5.1 WASTE DISPOSAL (SEWAGE AND PUTRESCIBLE WASTE)

An estimated 45 kL of sewage from the accommodation camp will be treated at a wastewater treatment plant each day during construction, and 15 kL during operation. The treated wastewater will be disposed of via irrigation to a dedicated area adjacent to the camp, sized in accordance with DWER requirements to minimise nutrient loading of the soils. The wastewater will be treated to a minimum low exposure risk level quality and licenced under Part V of the EP Act and the *Health Act 1911*.

The Proposal includes a landfill at an as yet undefined location within the Mine DE. A Landfill is required because the distance to any regional landfill is so great (over 100 km). Landfill applications are administered via Part V of the EP Act and will form part of the secondary approvals for the Proposal should it be required. An application will be prepared for a Class II or III Landfill.

Site selection and design are key elements in reducing the risk of contaminating the terrestrial environment from putrescible waste disposal. Based on less than 500 t/yr of waste, the landfill trench is expected to occupy less than 0.5 ha and will not require additional disturbance (providing a suitable site can be located within the planned disturbance areas). This is assessed as representing a very low risk of contamination to the key environmental value of Terrestrial Environmental Quality.

8.5.2 Mineral Waste

The geology and mineralisation of the Medcalf sill are well understood, and the sampling undertaken has been sufficient to characterise ore and waste materials in the context of mine closure. In reviewing the deposit geology and modelling it for mine planning, Cube Consulting (2019) stated that "based on the observed low nugget values, relatively long ranges, and the generally large thickness of the mineralisation, the search distances were not considered a limiting factor." This indicates a degree of uniformity and consistency that is important for both resource and reserve calculations and waste characterisation.

Waste material volumes are relatively low, with a strip ratio of approximately 0.15. All waste material is being mined from above the water table, and has been weathering in-situ over geological time scales. The small volumes of waste to be mined are therefore generally geochemically inert and benign, with negligible little potential for AMD (GCA 2020b).

Only pyroxenite from the cover horizon will be utilised for construction purposes. The Fe-rich cover materials within the upper mottled zone will therefore be segregated and stockpiled for later decommissioning and rehabilitation works. The cover fraction of the upper mottled zone is stable, and not prone to clay / sesquioxide dispersion with attendant erosion risks when located on sloped surfaces (GCA, 2020b). Although this material is weathered it remains physically competent, with its overall blocky/rocky nature making it well suited to managing the mottled and saprolite zone waste streams, which are susceptible to erosion. This is evidenced by the naturally self-armouring surficial soils within the Mine DE.

In terms of acidity and salinity the cover (upper mottled) zone is the natural substrate beneath the surficial soil profiles across the various Proposal activities. Use of the cover material in rehabilitation works will therefore reconfigure the pre-mining soil/substrate profile.

The gabbro and ultramafic materials account for $\approx 25\%$ and $\approx 30\%$ of the waste volume, respectively. The majority of these waste materials are present in the oxide (lower mottled and saprolite) waste zone. Analysis of samples from drillholes MRC127, MRC130 and MRC137 determined the lower oxide waste material (primarily gabbro and ultramafic, with a small portion of pyroxenite) is not suitable for use as a construction material for external surfaces due to its sodicity, swelling clay (smectites) content and decreasing ferruginisation with depth. Saprolite zone material is also likely to be erosive due to its sodic, saline, and smectitic properties. Lower mottled and saprolite zone waste streams will therefore be backfilled to the borrow pit or used for appropriate internal purposes.

8.5.3 Seepage from the TSF

The TSF will accept an estimated 7.2 Mt of tailings over the life of the Proposal, and the TSF design will be subject to mandatory assessment and regulation under both the Mining Act and Part V of the EP Act (Works Approval). The disposal of tailings into the TSF will also be licenced under Part V of the EP Act and regulated with mandatory annual geotechnical inspections and reporting. The assessment of seepage or spillage impacts from the TSF is based on the following:

- The geochemical characteristics of the tailings and resulting leachates;
- The receiving environment for those leachates;
- The potential pathways and sensitive receptors for leachates of concern; and
- The physical characteristics of the construction materials for the TSF and their potential to erode.

Tailings Characterisation

The tailings themselves and the embankment and capping construction materials generally represent the potential sources for contamination. Assessment of the solubility behaviour of tailings solids separated from supernatant water comprised batch reactor leaching buffered at pH 5 and kinetic testing of unsaturated tailings. Due to the strong water retention of the tailings resulting from high fine particle fraction and surface chemical forces, kinetic testing leachate volumes abstracted were small (GCA, 2020a).

<u>Acid-forming tendency</u>

The solids of both tailings samples were devoid of sulphides with Cr(II)-Reducible-S values below the detection-limit of 0.005%. They are also devoid of reactive carbonates (GCA, 2020a). They are classified as Non-acid Forming (NAF).

<u>Multi-element composition and mineralogy</u>

The Medcalf deposit formed by weathering of the primary silicates and minor element suites characterising the original 'source rock' lithochemistry over geological timeframes. All that remains within the oxide zone to be mined for Ti/V minerals are therefore 'resistates' (i.e. minerals so resistant to hydrolysis/dissolution during weathering that they have persisted to the present day, and become concentrated, as other minerals have weathered from the geology). The tailings mineral suite is therefore comprised of inert 'resistates' (i.e. the same minerals as in ore in situ, save for appreciably less amounts of the Ti/V-minerals recovered as concentrates).

The Medcalf mill will beneficiate ore through comminution, washing, and gravity separation. Processing will not include wholesale addition of acids/alkalis and the ensuing mineral dissolution/precipitation reactions. Furthermore, the process water will necessarily be of low salinity. Tailings water chemistry within the TSF is therefore controlled by weak interactions between (desalinated) process water and the inert resistates in the ore. Without any major influence from reagent chemistry, tailings water quality is very similar to that of potable water.

Mineralogy of the tailings solids are reported to be mostly hematite, goethite, and kaolin with subordinate anatase, rutile, and quartz. Tailings solids show major and minor element concentrations typically recorded for soils, regoliths and bedrocks derived from non-mineralised terrain. Minor enrichment was seen in Cu, Ag, Bi, and V, being noted by GCA (2020a) to be "within the range recorded for strongly ferruginous tailings-solids produced at hard-rock mines for a wide range of commodities throughout the WA mining industry (Campbell, unpublished results since the late-1980s)".

<u>Slurry Water and pH5 extracts</u>

Kinetic testing leachate pH was ≈ 7-8, typical of barren, NAF tailings, and the leachate assays indicated the geochemical stability of tailings metals/metalloids. The solubility testing undertaken thus shows the geochemical stability of minor elements at circumneutral pH values representative of the in-situ weathering pH regime of the tailings within the TSF.

The batch reactor leaching represented a 'worst case' pH regime for geochemical stability of minor elements (metals/metalloids). Only Mn and B exhibited increased mobility at pH 5. Neither element represents a significant risk, as the total Mn pool is limited, the elevated B concentrations were a function of feed solution rather than tailings B content, and elevated acidity is not representative of conditions within the TSF.

The slurry-waters for the samples were reflective of the process water used and the low solubility of the solids. They were recorded to be neutral, of 'potable salinity' and with a wide range of minor elements that were typically below, or close to detection-limits. Table 54 compares the tailings slurry water quality with baseline groundwater assays (only completed for selected elements). All analytes in the tailings slurry water are within the limits of natural groundwater. It also noted that the natural groundwater is hypersaline (54,000 - 170,000 mg/L Total Dissolved Solids (TDS) – or 2 - 5 times seawater salinity) and has no beneficial ecological use. Water of that salinity is toxic to plants and generally exceeds the tolerable salinity range for stygofauna (EPA, 2016j). The area is not a declared Groundwater area.

Multi-element analysis of tailings slurry waters and pH 5 extractions conducted by GCA (2020a) were compared to Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines (ANZECC, 2000) for livestock drinking water (as this would be the most likely local utilisation of any ground waters) (Table 54). The assessment for potential contamination includes comparison with Groundwater Investigation Levels (GILs) according to the National Environment Protection Measures (NEPC, 2011).

There were no exceedances of the livestock drinking water guidelines (ANZECC, 2000) for any of the recorded elements. Four minor exceedances were identified when compared to Freshwater GILs (NEPC, 2011) which included Cd, Cu, Ag and Zn, however all were recorded in very low concentrations. As the groundwater is hypersaline, is not potable and has no beneficial ecological use, and these exceedances are to freshwater guidelines, further investigations will be conducted to support detailed design and general seepage management from the TSF.

Table 54: Tailings Slurry water comparison with baseline groundwater

Analyte		Unit	Slurry water samples		Groundwater Sampling Results							
			DF	GR	MWH003 Sand	MWH003 bedrock	MWH001	MWH009	MWH012	MWH013	MWH014	Bore
Acidity/Basicity	pH	pH units	7.5	7	3.7	3.8	7.2	7	7.6	7.9	7.6	7.7
Conductivity	EC	µS/cm	1,090	750	100,000	110,000	140,000	170,000	89,000	55,000	56,000	54,000
Alkalinity	HCO_3 (as $CaCO_3$)	mg/L	27	18	<5	<5	180	120	520	680	710	760
Total Dissolved Solids	TDS	mg/L	600	410	76,000	85,000	120,000	160,000	62,000	41,000	42,000	36,000
Nitrate	NO_3-N	mg/L	0.15	<0.05	<0.2	<0.2	0.4	0.3	0.3	0.85	0.82	<0.2
Aluminium	Al	mg/L	0.027	0.026	63	16	0.25	<0.5	<0.25	<0.1	<0.1	<0.1
Calcium	Ca	mg/L	15	10	240	290	450	700	980	610	610	570
Iron	Fe	mg/L	<0.005	<0.005	54	86	<0.25	3.4	<0.25	<0.1	<0.1	<0.1
Magnesium	Mg	mg/L	10	15	3,400	4,000	4,700	6,600	2,900	1,700	1,700	1,700
Manganese	Mn	mg/L	0.035	0.42	1.4	2	2.1	2.6	1.1	0.63	0.7	0.7
Potassium	K	mg/L	6.8	5.2	260	230	340	540	200	120	120	110
Silicon	Si	mg/L	13	10	87	64	9.8	19	31	37	40	40
Sodium	Na	mg/L	180	110	18,000	22,000	34,000	44,000	17,000	10,000	9,900	9,400
Sulphate	SO_4	mg/L	89	57	8,900	11,000	12,000	15,000	5,700	4,300	4,300	4,200

Table 55: Comparison of slurry water and pH5 extracts with Guideline values

Analyte		Slurry water samples (mg/L)		Extraction under pH 5 (mg/L)		ANZECC (mg/L)	NEPM Investigation Levels for Soil and Groundwater (mg/L)	
		DF	GR	DF	GR	Livestock Drinking Water	Fresh Waters GILs	Drinking Water GILs
Acidity/Basicity	pH	7.5	7	5	5.1			
Conductivity	EC (µS/cm)	1,090	750	610	600			
Alkalinity	HCO3 (as CaCO3)	27	18					
Total Dissolved Solids	TDS	600	410			<2000		
Nitrate	NO3-N	0.15	<0.05			<400		50
Ammonia	NH3-N	5.1	5.7				0.9	-
Aluminium	Al	0.027	0.026	0.019	0.012	5	0.055	-
Antimony	Sb	<0.001	<0.001	<0.001	<0.001	-	-	0.003
Arsenic	As	0.005	0.002	<0.001	0.001	0.5	0.024 as As(III) 0.013 as As(V)	0.007
Barium	Ba	0.027	0.025	0.024	0.055	-	-	0.7
Bismuth	Bi	<0.001	<0.001	<0.001	<0.001	-	-	-
Boron	B	0.35	0.3	0.22	0.16	5	0.37	4
Cadmium	Cd	0.0009	0.0003	<0.001	<0.001	0.01	0.0002	0.002
Calcium	Ca	15	10	0.0022	0.0033	<1000	-	-
Chlorine	Cl	230	160	0	0	-	-	-
Chromium	Cr	<0.001	<0.001	<0.001	<0.001	1	0.001	0.05
Cobalt	Co	<0.001	0.001	0.016	0.029	1	-	-
Copper	Cu	0.004	0.005	0.017	0.033	<0.4	0.0014	2
Fluoride	F	0.4	0.3	<0.001	<0.001	2	-	1.5
Iron	Fe	<0.005	<0.005	0.007	<0.00005	Not sufficiently toxic	-	-
Lead	Pb	<0.001	<0.001	<0.001	<0.001	0.1	0.0034	0.01
Magnesium	Mg	10	15	0.0081	0.0069	<2000	-	-

Analyte		Slurry water samples (mg/L)		Extraction under pH 5 (mg/L)		ANZECC (mg/L)	NEPM Investigation Levels for Soil and Groundwater (mg/L)	
		DF	GR	DF	GR	Livestock Drinking Water	Fresh Waters GILs	Drinking Water GILs
Manganese	Mn	0.035	0.42	0.2	0.72	Not sufficientl y toxic	1.9	0.5
Mercury	Hg	<0.00005	<0.00005	<0.00005	<0.00005	0.002	0.00006	-
Molybdenum	Mo	0.0005	0.0006	<0.0005	<0.0005	0.15	-	0.05
Nickel	Ni	0.023	0.007	0.016	0.034	1	0.011	0.02
Phosphorus	P	<0.05	0.051	<0.05	<0.05	-	-	-
Potassium	K	6.8	5.2	0.0044	0.0028	-	-	-
Selenium	Se	0.001	0.002	<0.001	<0.001	0.02	0.011	0.01
Silicon	Si	13	10	0.012	0.0087			
Silver	Ag	<0.001	<0.001	<0.001	<0.001		0.00005	0.1
Sodium	Na	180	110	0	0			
Strontium	Sr	0.074	0.069	0.023	0.03			
Sulphate	SO4	89	57	0	0	<1000		
Thorium	Th	<1	<1	<0.001	<0.001			
Tin	Sn	<0.001	<0.001	<0.001	<0.001			
Titanium	Ti	<0.001	<0.001	<0.001	<0.001		-	-
Uranium	U	<0.001	<0.001	<0.001	<0.001	0.2	-	0.02
Vanadium	V	0.078	0.001	<0.001	<0.001		-	-
Zinc	Zn	0.033	0.05	0.026	0.073	20	0.008	-

	Above the Drinking water guideline
	Above the Freshwater GIL

Source: 200416 Tailings assessment raw data

Construction Materials

For completeness, the materials that will be used as part of the construction materials for the TSF and Evaporation Pond embankments and capping material for mine closure, were assessed for their geochemical characteristics.

The proposed Vesuvius, Fuji, Egmont, and Pinatubo Pits are "Oxide-Only" Pits with production of waste-regolith streams predominantly from the following Waste-Zones:

- Mottled-Zone which may locally be up to 10 - 15 mbgl; and

- Saprolite-Zone extending to pit-floors at ca. 50 mbgl.

The satellite Egmont and Pinatubo Pits are shallower than the Vesuvius and Fuji Pits. The top 4 - 5 m of the Mottled-Zone (Upper Mottled Zone) is largely comprised of iron-rich colluvium, conglomerate and laterite, with pisolitic gravels occurring commonly. This Upper-Mottled-Zone has been identified as an important resource of blocky, hard materials for construction and physical-stabilisation works.

pH and Salinity

Samples in the mottled zone are reported to be typically acidic with pH (1:2) values of 3.7 - 4.8 (GCA, 2020b) with the exception of one Gabbro (GB) sample with a pH (1:2) value of 8.4. All samples were also saline, with EC (1:2) values of 2.18 - 7.47 mS/cm. GCA (2020b) reports that the salinity reflects local and regional lacustrine influences, and the natural acidic state reflects the 'heavily-weathered/leached' nature of the sesquioxides and Fe/Al-oxyhydroxides, that predominate in the Mottled-Zone.

All samples in the saprolite zone were circum-neutral with pH (1:2) values of 6 - 8 (GCA, 2020b). Salinities ranged from moderate to extreme.

Acid-forming Tendency

The materials to be mined are oxidised materials with the waste-zones for all pits containing negligible-sulphides.

For the waste-zones for both the Vesuvius and Fuji Pits, of just over 1,000 samples, the mean-S value was 0.06 % (down to 50 m which is the depth of the pit-floors). The outliers were 0.29%, 0.32%, 0.34%, 0.90%, and 1.63% Sulphur (GCA, 2020b). For the satellite Egmont Pit, of 59 samples, a mean-S value was 0.05 % and for the satellite Pinatubo Pit, 408 samples had a mean-S value of 0.07%. The depth of both these pits will be less than 50 m.

All samples within the mottled zone contained 'negligible-sulphides' (viz. Sulphide-S ≤ 0.005%), and are classified as NAF. Acid-Neutralisation-Capacity values were typically 1 kg H_2SO_4/tonne.

All samples within the saprolite zone contained 'negligible-sulphides' (viz. Sulphide-S ≤ 0.007%) and are classified as NAF (GCA, 2020b).

Multi-elements and Solubility

Mottled Zone

Despite being generally acidic, the water-extract-Al concentrations ranged up to 1.6 mg/L. Solubility behaviour conclusions by GCA (2020b) are:

- Salinity is rapidly depleted during leaching with an increasing trend in pH;
- Al solubility is closely tied to salinity, and swiftly drops from the multi-mg/L range initially, to the sub-mg/L range as leaching progresses; and
- Soluble-Zn forms are present initially, but are swiftly eluted during leaching. The 'pools' of such soluble-Zn forms are within the 5-10 mg/kg (dry-solids basis) range, and thus constrained.

Saprolite Zone

Assays showed enrichment in Cu, Ni, Cr, Co, and Bi. The water-extracts were characterised by minor-element concentrations either below, or near, detection-limits.

Materials Balance

Construction materials are required during the Proposal construction and operation phases for the TSF and EP embankments. There is not enough waste material suitable for construction available from the mine pits alone, due to the low strip ratio (Table 56). Pyroxenite waste (the only waste rock type considered suitable for construction) only contributes to 21% of the waste materials. Construction materials will therefore mostly be sourced from an onsite borrow pit (basalt), potentially supplemented with cover horizon pyroxenite sourced from the mine pits depending on staging. Up to 2,9 Mm^3 of fresh basalt construction material is potentially available from a borrow pit immediately south of the Vesuvius pit (Table 57).

Table 56: Mine Pit Waste Volumes

Waste Volumes from Mine Pits				
Regolith	**Code**	**Rock type**	**Volume (m^3)**	**Use**
Cover	Cover	Gabbro	72,000	Backfill
		Pyroxenite	595,000	Construction
		Ultramafic	29,000	Backfill
Oxide	Mottled zone	Gabbro	115,500	Backfill
		Pyroxenite	0	
		Ultramafic	106,500	
Transitional	Saprolite	Gabbro	115,500	Backfill
		Pyroxenite	9,500	
		Ultramafic	235,500	
Total			**1,278,500**	

Table 57: Borrow Pit Construction Material Volumes

Waste Volumes from TSF borrow pit				
Regolith	**Code**	**Rock type**	**Volume (m3)**	**Use**
Fresh	Fresh	Basalt	2,938,000	Construction
Total			**2,938,000**	

Construction materials will be required during closure for abandonment bunds, TSF closure crest bunds, and TSF top surface cell bunds, and armouring of TSF embankments and the western drainage channel. In addition to fresh basalt construction material sourced from the borrow pit, the evaporation pond embankment material will be reformed into construction material for the integrated TSF and evaporation pond closure landform. Waste rock other than cover pyroxenite and borrow pit basalt will be used for borrow pit backfill.

A construction materials balance for operations and closure is provided in Table 58. Sourcing construction material from the borrow pit in addition to the mine pits provides the Proposal with

3,5 Mm^3 of construction material in total. 3.06 Mm^3 of waste rock is required providing a positive waste rock balance of 0.47 Mm^3.

The evaporation pond embankments will be removed during closure and the embankment construction material repurposed for use in the TSF top closure crest bund, TSF cover layer, and evaporation pond cover.

As closure planning progresses, the TSF design may be further developed to incorporate storage of evaporation pond residues / precipitates. In that case fresh basalt additional to that used in the current materials balance may be required for a larger / thicker capillary barrier. Alternatively, a smaller / shallower borrow pit may be possible, depending on further development of waste storage and other strategies. The construction materials balance also shows a positive balance of +129,220 m^3 of evaporation pond embankment material. This may be utilised to form a thicker TSF cover than that designed at this preliminary stage, or may be utilised as borrow pit backfill at closure.

Topsoil will be stripped to a depth of 0.1 m from most mine activity disturbance areas and stockpiled at the Topsoil Stockpile. Topsoil excavated from the roads and bore field will be stockpiled in windrows at the perimeter of these disturbance areas. It will be re-spread back on to these areas (which may be retained post-closure, depending on stakeholder agreements) for rehabilitation. These disturbance areas are therefore not included in the topsoil materials balance.

Rehabilitation materials (topsoil) will be required during closure to rehabilitate the TSF top surface and embankments, and the footprints of the evaporation pond, camp, process water dam, workshop, rom pad, admin office, plant site, pit surround, overburden stockpile, settlement pond, and eastern section of the diversion drain. Topsoil will generally be reapplied at a thickness of 0.1 m, with the exception of 0.15 m on the TSF top surface and embankments, and the evaporation pond footprint.

The mine pits and pit abandonment bunds will not be rehabilitated with topsoil. The northern and western sections of the TSF / evaporation pond diversion channel also will not require topsoil application, as they will be rock armoured at closure. The eastern section will be rehabilitated with topsoil. The topsoil material balance is summarised in Table 58. There is no waste rock landform to rehabilitate as the waste generated from the pits will be backfilled for the borrow pit reducing the borrow pit volume by ≈23% (Table 60).

Table 58: Operations and Closure Construction Materials Balance

<table>
<tr><th colspan="7">Operations</th><th colspan="3">Closure</th></tr>
<tr><th>Source</th><th>Regolith</th><th>Code</th><th>Rock Type</th><th>Volume (m^3)</th><th>Destination</th><th>Construction Volume (m^3)</th><th>Source</th><th>Destination</th><th>Construction Volume (m^3)</th></tr>
<tr><td>Mine Pits</td><td>Cover</td><td>Cover</td><td>Pyroxenite</td><td>595,000</td><td>TSF</td><td>1,550,000</td><td rowspan="5">Borrow Pit
(volume taken as required)</td><td>Abandonment Bunds</td><td>55,680</td></tr>
<tr><td>Borrow Pit</td><td>Fresh</td><td>Fresh</td><td>Basalt</td><td>2,938,000</td><td>Evaporation pond 1</td><td>585,000</td><td>Capillary break (0.3 m + 0.2 m loss through tailing surface)</td><td>242,000</td></tr>
<tr><td colspan="5" rowspan="6"></td><td rowspan="6">Evaporation pond 2</td><td rowspan="6">590,000</td><td>TSF interface rock armour</td><td>5,000</td></tr>
<tr><td>TSF embankment rock armour</td><td>30,000</td></tr>
<tr><td>EP interface rock armour</td><td>4,500</td></tr>
<tr><td rowspan="3">EP embankments
(585,000 + 590,000 m^3))</td><td>TSF crest bund</td><td>56,220</td></tr>
<tr><td>TSF Cover layer (0.5 m)</td><td>242,120</td></tr>
<tr><td>EP cover</td><td>747,440</td></tr>
<tr><td colspan="4">TOTAL WASTE ROCK</td><td>3,533,000</td><td>TOTAL CONSTRUCTION MATERIAL</td><td>3,062,180</td><td colspan="2">TOTAL CLOSURE MATERIAL</td><td>1,382,960</td></tr>
<tr><td colspan="6">WASTE ROCK CONSTRUCTION AND CLOSURE BALANCE</td><td>+ 470,820</td><td colspan="2">EP EMBANKMENT CLOSURE MATERIAL BALANCE#</td><td>+ 129,220</td></tr>
</table>

#Excess of 129,220 m^3 based on using EP embankments to cover EP pond and TSF footprint. Excess to Borrow pit.

Table 59: Rehabilitation material (topsoil) balance

Mine Activity	Area (ha)	Topsoil Depth (m)	Topsoil Excavated (m^3)	Topsoil Cover (m)	Topsoil Reapplied (m^3)
Camp	10.0	0.10	10,050	0.10	10,050
Process Water Dam	1.2	0.10	1,171	0.10	1,171
Workshop	0.7	0.10	750	0.10	750
ROM Pad	3.4	0.10	3,400	0.10	3,400
Admin Office	0.5	0.10	500	0.10	500
Pinatubo Pit	5.8	0.05	2,903	0.00	0
Egmont Pit	2.0	0.05	978	0.00	0
Bore Field	0.8	0.10	760	0.10	760
Evaporation Pond	75.2	0.10	75,155	0.15	113,213
Plant Site	5.3	0.10	5,335	0.10	5,335
Vesuvius/ Fuji Pit	31.5	0.10	31,509	0.00	0
TSF	65.2	0.15	97,875	0.15	94,258
Pit Bund	3.0	0.00	0	0.00	0
Pit Surrounds	12.5	0.10	12,534	0.10	12,534
Borrow Pit	14.7	0.10	14,684	0.10	14,684
Topsoil Stockpile	11.6	0.00	0	0.00	0
Overburden Stockpile	19.3	0.10	19,272	0.10	19,272
Settlement Pond	2.0	0.10	1,999	0.10	1,999
Roads	25.3	0.10	25,341	0.10	25,341
Diversion Drain	2.0	0.10	2,006	0.10	501
TOTAL	**292.1**		**306,220**		**303,767**
				BALANCE	**+2,452**

Table 60: Borrow pit waste rock backfill volumes

Backfill volume for TSF borrow pit	
Rock type	**Volume (m^3)**
Gabbro	303,000
Ultramafic	371,000
Pyroxenite SP	9,500
Total backfill	**683,500**

TSF Conceptual Design

TSF design work has been completed to concept design stage (Golder, 2020). Pending environmental approvals, detailed design will be completed to inform secondary approvals under Part V of the EP Act (Works Approval and Licence) and the Mining Act (MP and MCP). Details of the TSF design have been provided in Section 2.2.3.

The TSF is not proposed to be lined – the tailings geochemical characteristics represent a low toxicity risk, and as the slurry water will be fresh and the groundwater deep and hypersaline (with no beneficial use), the environmental risk associated with allowing managed seepage is considered low.

Receptors

Sensitive receptors are noted to be:

- Sub-populations of *M. aquilonaris;*
- Populations of Priority Flora;
- The Bremer Range Vegetation Complexes PEC; and
- General flora and fauna.

The TSF is located downslope from all sub-populations of *M. aquilonaris*. Groundwater under the sub-populations is estimated to be around 40 - 50 mbgl. Even under the unlikely scenario of a TSF failure, there is no pathway for tailings or tailings seepage from the TSF to affect *M. aquilonaris*.

More generally, there are other potentially Threatened Flora, and the Bremer Range vegetation complexes Priority 1 PEC known to occur within the Mine DE as described in Section 5. Direct impacts associated with vegetation disturbance have been assessed under Flora and Vegetation (Section 5). This section assesses the potential for contamination from seepage or spillage from the TSF.

Seepage

Groundwater under the proposed TSF site is hypersaline (36,000 - 160,000 mg/L TDS) and is estimated to be at a level of 305 - 310 m Australian Height Datum (AHD). The lowest surface elevation for the proposed TSF is 340 m AHD, with a separation between the base of the TSF and the baseline groundwater of 30 - 40 m (Golder, 2020). This layer can be expected to convey seepage, forming a mound under the TSF. Strong downward heads and gradients will apply due to the distance to groundwater.

As the process will operate with desalinated water, the tailings seepage is predicted to be fresh and therefore the likelihood of hypersaline groundwater impacting vegetation around the TSF is remote.

Despite the fact that TSF seepage will be fresh, and hence any shallow sub-surface seepage is not expected to affect plant roots, seepage may impact on the aquifer downslope by applying hydraulic pressure and raising groundwater levels downslope. The mitigation of this will be considered in detailed design for the TSF via a more detailed and extensive seepage model. Options to mitigate seepage from the TSF include:

- Under drainage system to reduce seepage;
- Deep monitoring and pump-back bores located downslope;
- Compacted in-situ materials in the base of the TSF; and
- Use of liners.

The potential for seepage is usually assessed based on the detailed design of the TSF and is required for both the Works Approval and Mining Proposal. A system of monitoring bores will be proposed with trigger values based on groundwater level designed to identify groundwater approaching root zone within the downslope vegetation. Given the low throughput of the operation (0.5 Mtpa of tailings annually) and significant separation between base of TSF and groundwater, it is unlikely that pump-back bores to maintain groundwater separation from root zone would be required. Further detail regarding mitigation measures is provided in Section 8.6.2.

Summary

Tailings spillage could occur if the tailings pipes split or fail. Controls to limit the likelihood of tailings pipe failures and limit the extent of any spillage are proposed.

The assessment of geochemical characteristics of the tailings combined with the natural characteristics of the site shows:

- The potential for impact upon conservation significant species from TSF seepage into groundwater is negligible as they are located upslope from the TSF;
- The potential for seepage into groundwater from the TSF to impact upon surrounding vegetation is low, as the depth to groundwater is around 30 - 40 m and the tailings slurry water will be fresh;
- The environmental impact of tailings spillage is limited to the potential for tailings solids to cover plants. Tailings slurry water will be fresh and not toxic to plants.

Based on the information provided above, environmentally significant impacts to terrestrial environmental quality from tailings seepage are considered unlikely, and the detailed design and approval processes under Part V of the EP Act and the Mining Act are expected to ensure that the EPA objective for this factor can be met.

8.5.4 Post-Closure Landforms and Hydrology

Tailings Storage Facility

The TSF location and design is subject to site geotechnical investigations and may vary in location to the layouts and conceptual designs presented herein. Mine Earth (2020) developed a conceptual closure design for the Project TSF and evaporation ponds (EP1 and EP2) as designed by Golder (2020). Mine Earth (2020) identified appropriate design standards, assessed closure risks, and accordingly developed a TSF design approach. Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) volumes were calculated, a water balance calculated, and a TSF cap designed to contain the total predicted storage volume of 1.04 Mm^3. The Mine Earth (2020) TSF closure design report is included as Appendix 7.6.

The post-closure TSF landform is designed to meet the following closure outcomes:

- Comply with legally binding obligations, conditions and commitments relevant to rehabilitation and closure;
- Safe, stable and non-polluting;
- Support hydrological flows for 90% percentile rainfall events;
- Generate water runoff and leachate from rehabilitated areas with quality compatible with the maintenance of local environmental values;
- Will not adversely affect surface and groundwater hydrological patterns/flows;
- Feature rehabilitated areas functionally analogous to pre-Project land use; and
- No unacceptable down-gradient impacts of erosion from TSF surfaces

The key post-closure risks to be managed to achieve the above outcomes for the TSF are:

- Management of incidental rainfall and upstream runoff that reports to the TSF top surface and the TSF embankment;
- If evaporites are buried within the TSF, manage potential salt-rise from the evaporites;
- Erosion of TSF embankments;
- Drainage management and erosion of the TSF top surface; and
- Generation of tailings dust.

The post-closure TSF landform has been designed with an internally draining top surface. This approach capitalises on the life-of-mine tailings surface, which drains internally with a predicted beach angle of 0.5%. It will be engineered to contain the PMP event with a starting water level aligning with the maximum water level in a 90% percentile wet year whilst maintaining a 300 mm freeboard.

The conceptual closure design has avoided reliance upon drainage conveyance features where practicable. To function effectively drainage features such as diversion drains and spillways require ongoing inspection and maintenance, which is typically undesirable for a passive closure solution. It has therefore been assumed that the diversion drain at the landform/natural slope interface fails at some point and the upstream catchment reports to the TSF.

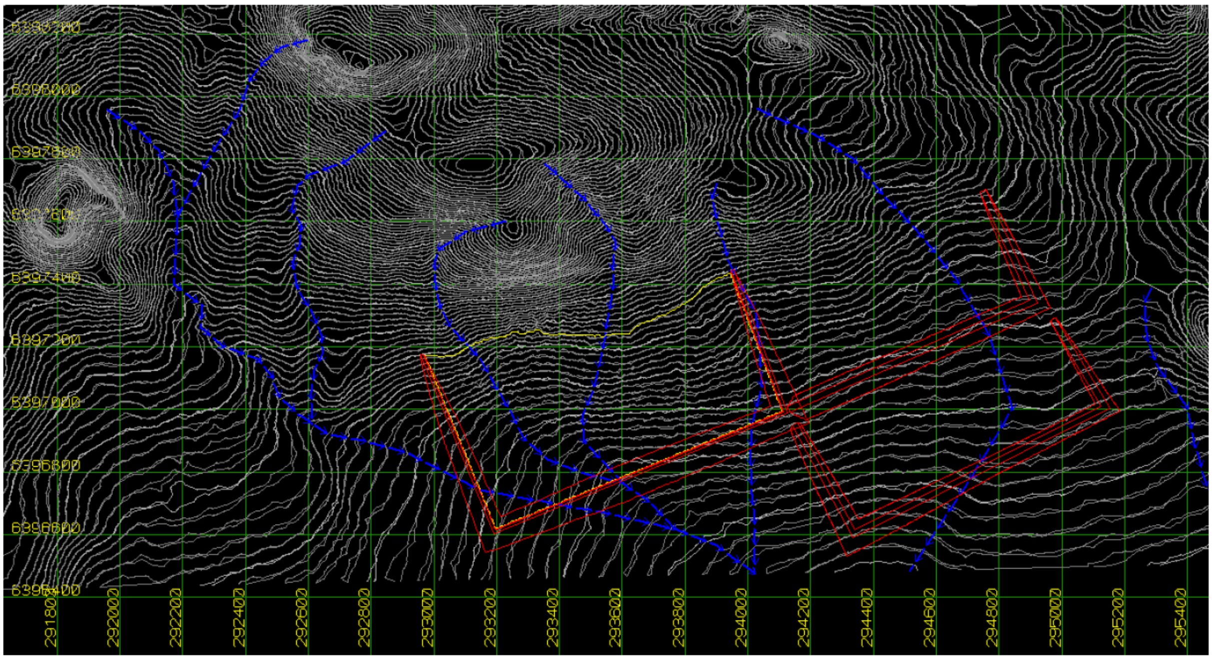


Figure 99: Inferred pre-mining drainage lines relative to the TSF and Evaporation Ponds

The conceptual closure design surface is presented in Figure 100 - Figure 103. Closure embankment material will be sourced from evaporation pond embankments. A total cap thickness (including topsoil) of up to 0.95 m has been adopted for the conceptual design:

- 0.3 m (+ 0.2 m loss through tailings surface) capillary break layer (coarse material with low fines sourced from the borrow pit) at the TSF top surface over any EP precipitates and/or residues stored within the TSF;
- 0.5 m cover (sourced from EP embankments) over TSF top surface; and
- 0.15 m layer of topsoil (on TSF top surface and embankments, excluding the top surface of the crest bund).

Figure 100 shows a typical section of the closure embankment, required to retain upgradient surface water flows and incident rainfall and prevent overtopping.

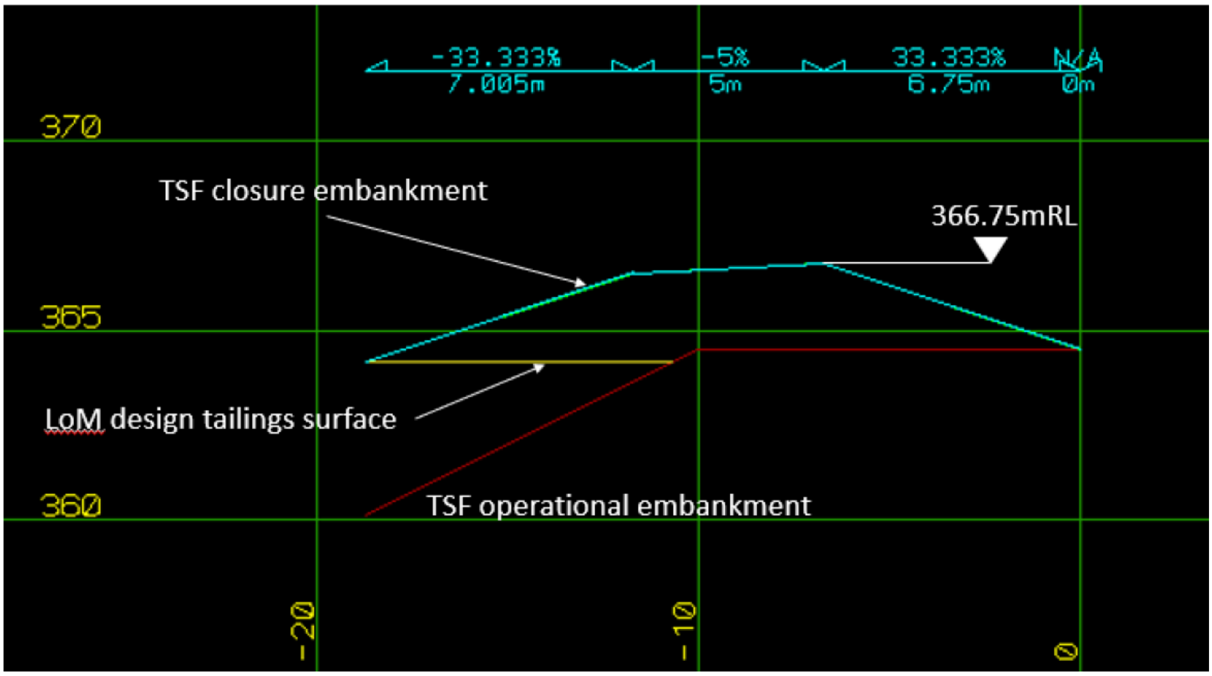


Figure 100: TSF embankment conceptual design cross-section

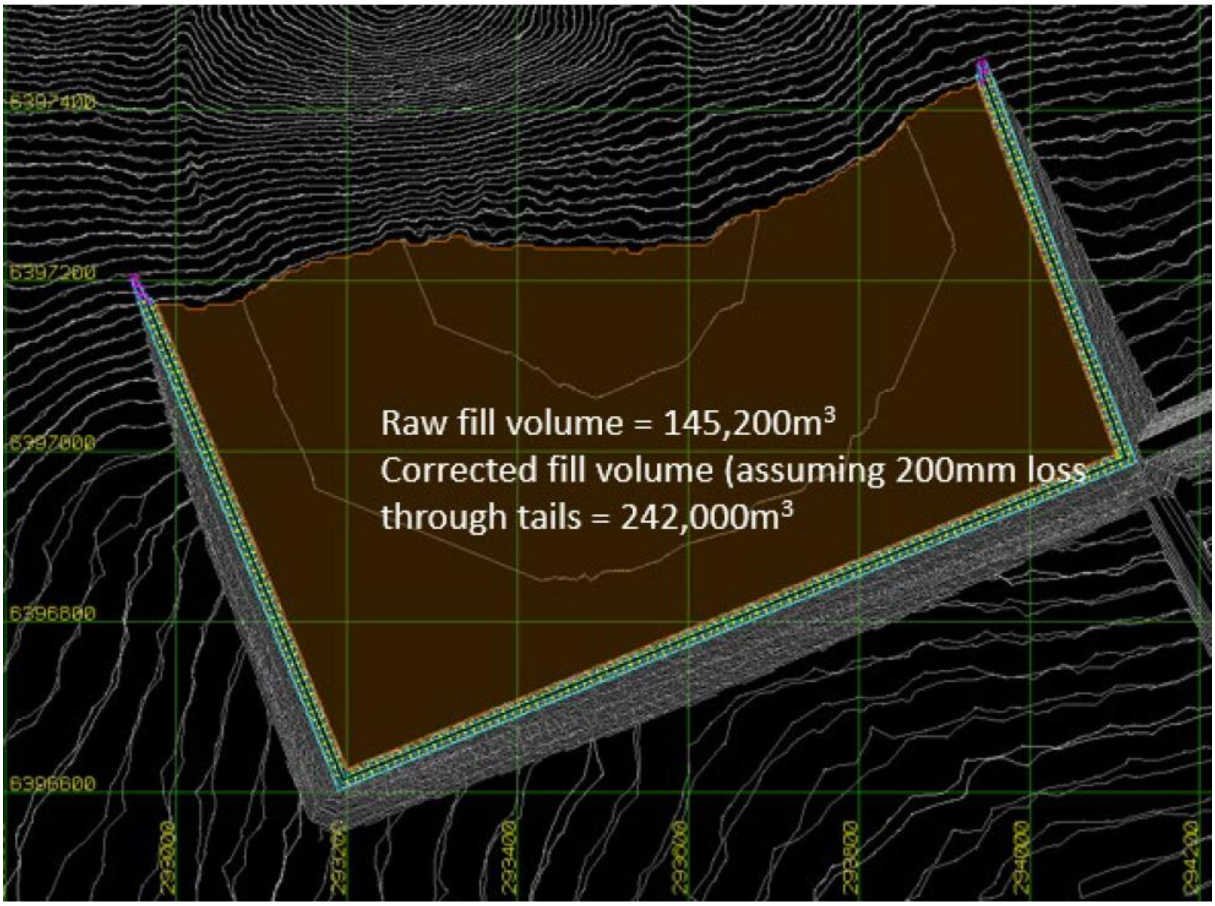


Figure 101: TSF conceptual closure surface, after construction of capillary break layer (0.3 m + 0.2 m loss through tailings surface)

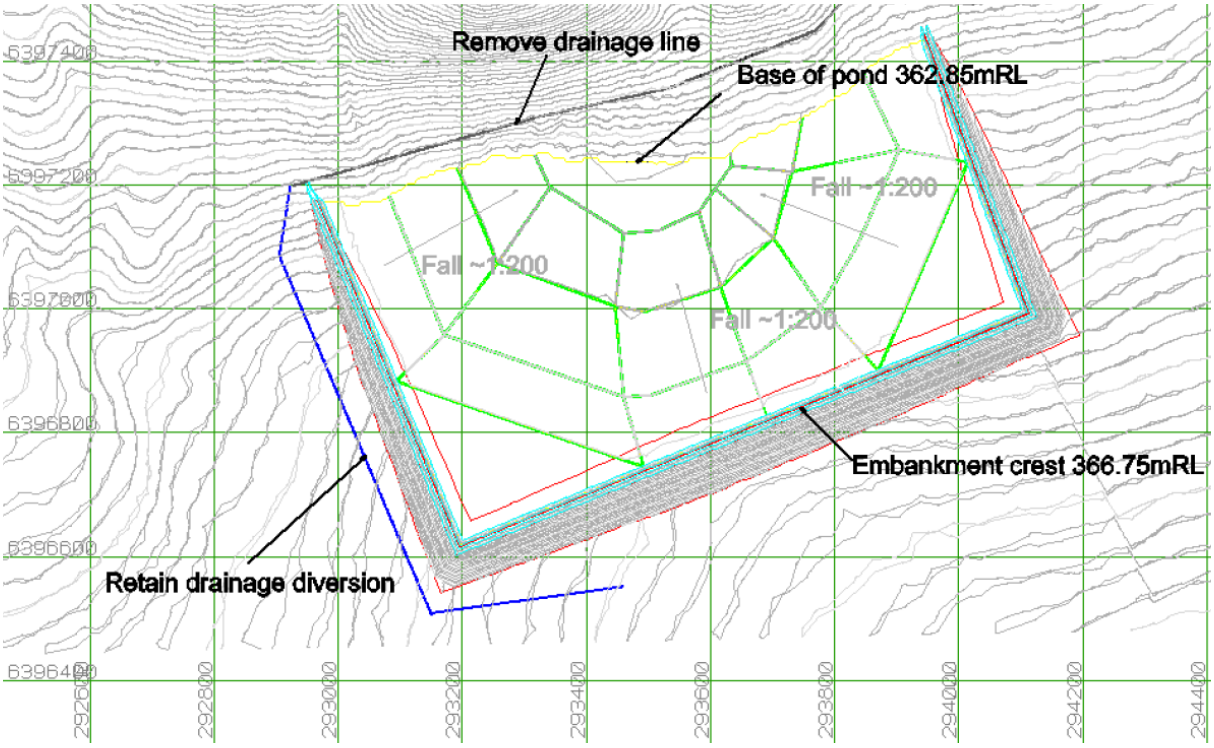


Figure 102: TSF cover conceptual design surface

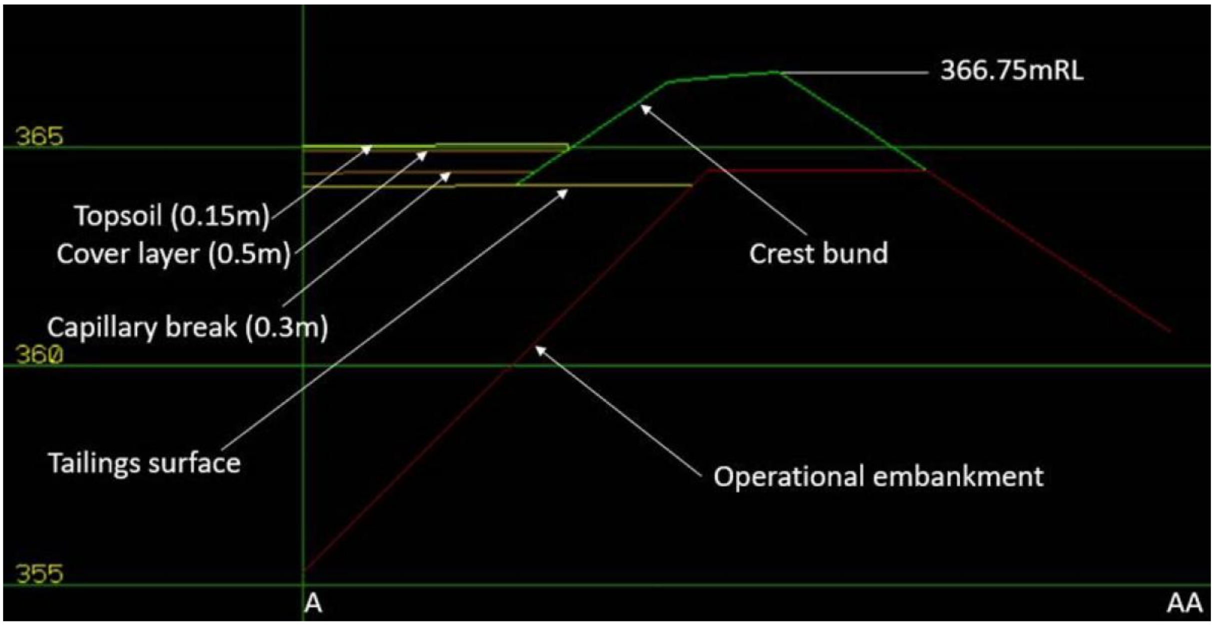


Figure 103: SF crest bund and cover detailed section

TSF top surface cell bunding has been included to partition water during more frequent rainfall events to reduce the potential for ponding at the low point, improve the water balance for the TSF by increasing infiltration and evaporation losses, and increase water availability for vegetation across the TSF. Cell bunds will be constructed from locally pushed up cover material to a nominal height of 0.75 m so as to not impact upon the storage of extreme rainfall events within the TSF.

For the purpose of calculating a materials balance it has been assumed that a 450 m length of the western embankment will require rock armouring to a height of 1 m. It has been assumed that the rock armour will be basalt sourced from the borrow pit.

Mine Earth (2020) calculated a water balance for the conceptual TSF closure design to confirm it will meet the selected design standards. When the PMP was applied to the maximum 90th percentile water level, the water balance predicted a maximum water level of 366.4 mRL, 50 mm below the maximum design water level. The conceptual closure design for the TSF therefore meets the design standards for water storage

Evaporation Ponds

The key post-closure risks to be managed for the evaporation ponds are:

- Salt impacts to the environment;
- Long term stability of the evaporation ponds embankments; and
- Scour from concentrated flows over the EP footprint, especially in the event of concentrated flows that may result from the failure of the upstream drainage diversion.

The design approach for the EPs consists of:

- Remove the evaporation ponds diversion drains;
- Remove contaminants such as residue and salt impacted soils to manage the vertical migration of salt;
- Remove the evaporation ponds embankments;
- Construct a cover over the impacted pond area to manage vertical migration of salt;
- Rock armour drainage concentration areas within the evaporation ponds footprint; and
- Apply topsoil to the evaporation ponds footprint.

Saline evaporation ponds evaporites will be removed from the pond base at closure and stored and/or disposed of such that Project closure objectives are met. A series of options have been identified, materials requirements identified and considered. The storage/disposal options for the evaporites include:

- Storage in the adjacent TSF (beneath a capillary break layer forming part of the TSF top surface cap);
- Storage in the borrow pit or one of the completed mine pits; or
- Removal to an appropriate offsite facility.

Final selection of an evaporation ponds evaporite management strategy will consider further waste characterisation (salinity and volumes), logistics (e.g. availability of appropriate offsite disposal facilities and transport arrangements) and cost.

The remaining EP embankment material will be reprofiled to form a minimum 1 m cover over the EP disturbance area. Where upstream drainage reports to the cover area, the cover will be tied into these areas at a grade of 1% to prevent ponding and form a free-draining surface at the interface of the cover and natural ground. Downstream facing areas will be graded to tie in with the surrounding areas (e.g. ≈ 20%). Drainage concentration areas within the evaporation ponds footprint and at the upstream interface between natural ground and the evaporation ponds footprint cover will be rock-armoured. A minimum 150 mm of topsoil will then be applied to the EP disturbance area. The drainage diversions around the north and east of the evaporation ponds will be backfilled.

Integrated Tailings Storage Facility and Evaporation Pond Landform

The final post-closure integrated TSF and EP landform conceptual design surface and sections is presented in Figure 104.

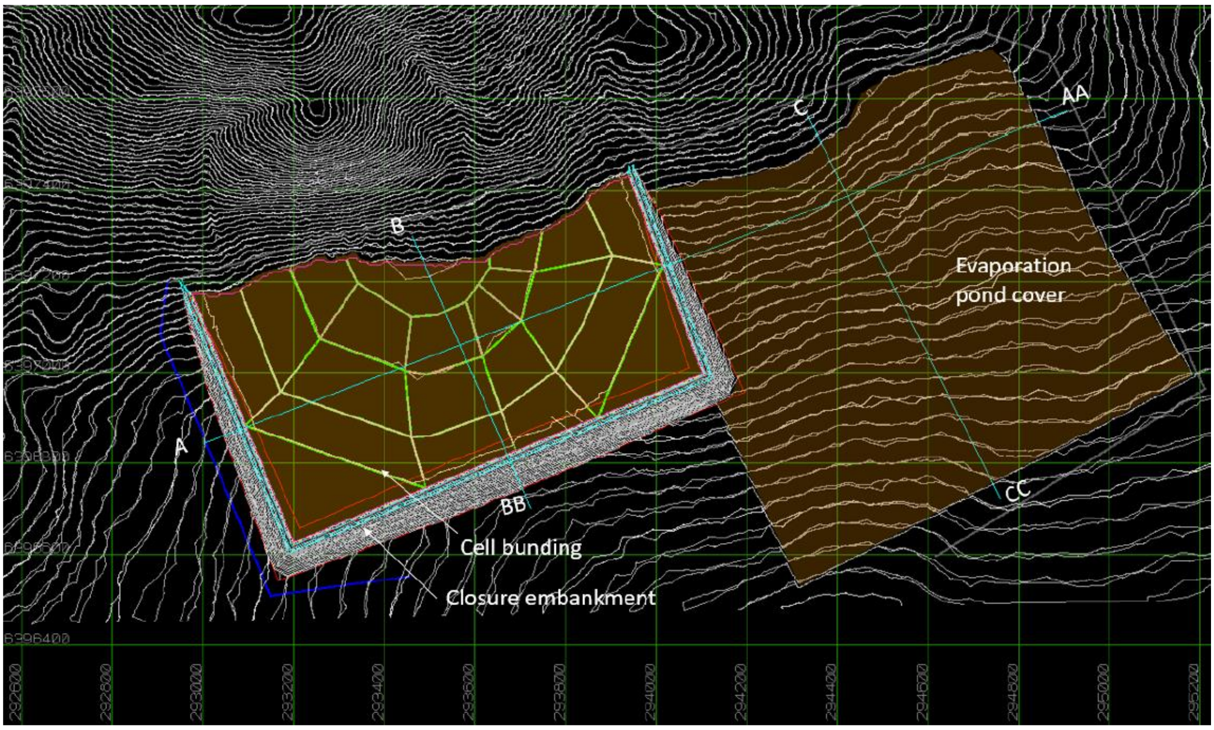


Figure 104: Integrated Tailings Storage Facility and Evaporation Pond Post-Closure Design

8.5.5 Tailings Spillage

Tailings spillage may occur from:

- Pipeline breaks;
- TSF overfilling / overtopping; or
- TSF embankment failure.

Tailings will be transported from the Process Plant to the TSF via a gravity-fed pipeline. A rupture of this pipeline has the potential to contaminate the surrounding soils if it were to occur. Leak detection is proposed for this pipeline, with an automatic shut-down of the pipeline tailings feed. This will restrict the volume of tailings that would be released into the surrounding environment. Audalia will also investigate the option of containing a spill if it were to occur, by placing the pipes in a system of bunds and sumps designed to contain spillage. This option however may not be pursued given the benign nature of the tailings and the additional clearing of vegetation required to develop this containment infrastructure. The details of these systems are generally planned and managed via a Works Approvals under Part V of the EP Act and a MP under the Mining Act. Additional mitigation measures are proposed in Section 8.6 to minimise the change and potential impact of a tailings pipelines spill.

The TSF will be constructed in accordance with a Detailed Design Report, and operated in accordance with an Operating Manual that will both be assessed by DMIRS as part of the MP, and DWER as part of the Works Approval process. These documents will provide design and operational measures that will ensure that the risks of overtopping and embankment failure are minimised in accordance with DMIRS and DWER requirements. As with most mining operations within WA, a TSF embankment failure has the most significant environmental consequences and requires strict adherence to the required controls.

Based on the information provided above, environmentally significant impacts to terrestrial environmental quality from tailings spills are considered unlikely, and the detailed design and approval processes under Part V of the EP Act and the Mining Act are expected to ensure that the EPA objective for this factor can be met.

8.5.6 Hydrocarbon spills

Diesel use at the Proposal is predicted to be 18,504 kL/yr for all site and transport operations (Just Design Engineering, 2019; Appendix 9). In addition to diesel used for mobile equipment, the power station will be diesel-fired, and small generators may be used for mobile power around the site. A 400 kL diesel storage is required for power generation and emergency diesel engines at the mine. Two other fuel facilities are likely to support the mining fleet (around 80 kL) and a 440 kL fuel transfer station will be installed near the Esperance Norseman road. These diesel storage facilities will have secondary containment; they will either be either self-bunded or located within bunded areas. No fuel will be stored upslope of the critical habitat of *M. aquilonaris*.

In addition to diesel fuel, most earthmoving equipment uses hydrocarbon based materials for hydraulics, and failed hydraulic systems can result in relatively small hydrocarbon spills. Considering the above, and the small scale of operations planned for Medcalf, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon contaminated soil that can be remediated via passive means such as bioremediation. Proposed control measures are identified in section 8.6 and are designed to further reduce the risk of soil contamination from hydrocarbon spillage.

8.5.7 Seepage, leaks or spills of saline water

Saline water seepage, leaks or spills may occur from the evaporation ponds or saline water pipelines.

Evaporation Ponds

The groundwater sources to be utilised for the Project are saline to hypersaline (36,000 - 160,000 mg/L TDS). A large portion of this water will need to be desalinated for processing and potable water supplies via a RO desalination plant. Reject water from the RO Plant will be hypersaline (100,000 - 120,000 mg/L TDS) and will be pumped to the evaporation ponds.

The evaporation ponds are designed to have a compacted base, but will not be lined, to reduce their size, and to avoid the issues associated with the appropriate disposal of a HDPE liner at closure. As such, saline water is predicted to seep into the underlying soils, raising the salinity of these soils considerably for the life of the Proposal, and several years afterwards.

This impact is not predicted to be permanent and was considered unlikely to result in impacts beyond the footprint of the evaporation ponds. The underlying groundwater is 30 – 40 m deep in this location, and is already saline, with no beneficial uses.

Saline Water Pipelines

Saline water pipelines will run from the borefield to the RO Plant, then from the RO Plant to the evaporation ponds. A rupture of these pipelines has the potential to contaminate the surrounding soils if it were to occur. Leak detection is proposed for these pipelines, which will trigger an automatic shut-down of the borefield or RO Plant feed. This will restrict the volume of saline water that would be released into the surrounding environment. Audalia will also investigate the option of containing a spill if it were to occur, by placing the pipes in a system of bunds and sumps designed to contain spillage. This option however may not be pursued along the whole length of the pipelines as the area likely to be affected by a spill may be less than the clearing of vegetation required to develop this containment infrastructure. The details of these systems are generally planned and managed via a Works Approvals under Part V of the EP Act (for the RO Plant, evaporation ponds and Process Plant) and a MP under the Mining Act. Additional mitigation measures are proposed in Section 8.6 to minimise the change and potential impact of a saline water pipeline spill.

Summary

Based on the information provided above, environmentally significant impacts to terrestrial environmental quality from saline water spills are considered unlikely, and the detailed design and approval processes under Part V of the EP Act and the Mining Act are expected to ensure that the EPA objective for this factor can be met.

8.5.8 Erosion and Sedimentation

Mine Area

Surface water flows through the mine area have the potential to result in the erosion of cleared areas, and the subsequent deposition of sediment into the downslope environment.

Soil studies by Western Horticultural Consulting (2019) have determined that the topsoil materials within the mining area are generally sandy loams, non-saline (with the exception of the subsoil of the 'Alkaline red shallow loamy duplex' soil), not sodic, with moderate to high levels of organic carbon. Some soils are rocky, and all soils generally contained 20 - 50% gravel, with some soils containing up to 80%. The topsoils represent valuable materials for rehabilitation as they will not only provide a valuable seed bank, but their gravelly and stony nature will assist in resisting erosion.

Topsoil and mottled zone materials from the top 4 - 5 m of the profile have been characterised as non-dispersive (Emerson Class Number of 6 and are non-dispersive – GCA, 2020b) and are noted represent useful erosion-resistant materials for rehabilitation of built landform slopes. The deeper mined materials are noted to be sodic, and typically highly dispersive with Emerson Class Numbers of either 1 or 2 as expected from their general elevated salinity. Swelling clays (smectites) were also reported by GCA (2020b). Saprolite materials represent an erosion risk and will need to be managed to ensure that they do not form the surface of any rehabilitation of built structures.

Based on the above, the majority of the soils within the mine area are unlikely to present a significant erosion risk. However, there are some materials that will require management, and erosion controls have been proposed in Section 8.6 to minimise these risks.

Haul Road

Linear infrastructure features such as the Haul Road can create erosion of soils, particularly where inadequate allowance is made for drainage. Raiter (2016) reviewed the occurrence of soil erosion associated with linear infrastructure in the Great Western Woodlands and identified a high level of association between linear infrastructure and erosion frequency and severity. Many of the linear infrastructure features in the Great Western Woodlands have been constructed with very basic approaches and machinery.

The risk of significant erosion caused by the Haul Road can be significantly reduced by adopting sound surface water design principles. GRM (2020a) have assessed surface water drainage and recommended 28 crossings, with accommodation of shallow overland flow areas to reduce the risk of concentrating flows and causing erosion (refer to Section 9 for further detail).

NSW Office of Environment and Heritage (2012) have prepared guidance on erosion and sediment control on unsealed roads. The principles of this guidance have been adopted as the design basis for the road drainage to reduce the risk of causing erosion.

Based on the above, the Haul Road is to be constructed such that it will not present a significant erosion risk. These design commitments are detailed in Section 8.6.

8.5.9 Disturbance of Acid Sulphate Soils

The receiving environment is not within Class I or Class II areas as per the ASRIS ASS mapping. Areas where ASS are generally found are identified by DER (2015). The only potential ASS area identified in DER (2015) that may occur within the DEs is:

> *"xv) areas where the dominant vegetation is tolerant of salt, acid and/or waterlogged conditions e.g. mangroves, salt couch, swamp-tolerant reeds, rushes, paperbarks and swamp oak (Casuarina spp.)."*

An assessment of the vegetation mapping presented in Section 5 reveals that vegetation type 'samphire vegetation (CD-CSSSF1)' occurs within an estimated 60 m section of the Haul Road DE, approximately 1.5 km from the western end of the Haul Road where it crosses the Lake Medcalf tributary (Figure 41).

GRM (2020a) identified this section of the road as "crossing 1" and note that it is the only section of the road requiring a causeway. Construction of the causeway will entail an elevated section of fill and placement of culverts and/or a floodway section for significant flow events. This activity does not require excavation of the soils. On this basis, the risk of contamination from disturbance of ASS is considered to be negligible.

8.6 Mitigation

Audalia has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise rehabilitate, offset. Offsets are not expected to be required for this factor.

8.6.1 Avoid

The Proposal has been designed to avoid the following potential impacts:

- Waste rock dump impacts by utilising mined waste rock materials in the construction of embankments for the TSF and Evaporation Ponds;
- On-site contamination risks from the chemical processing of ore by conducting this offshore; and
- Disturbance of Potential ASS by constructing a causeway at “crossing 1” without excavating in-situ soils.

8.6.2 MINIMISE

The following mitigation measures are proposed to ensure that direct and indirect impacts to terrestrial environmental quality are minimised:

1. **Obtain and comply with Works Approval and Licence issued under Part V of the EP Act.** A Works Approval and Licence will be required for the Proposal, specifically for the Process Plant, TSF, RO Plant, evaporation ponds, sewage treatment plant and landfill. These items present the highest pollution risks for the Proposal. Therefore the Works Approval and Licence is the primary mechanism for ensuring the design and operation of the Proposal is conducted in a manner that minimises pollution impacts to terrestrial environmental quality. The Works Approval and Licence will ensure that the following mitigation measures are implemented at a minimum:
   a. Sufficient freeboard will be included in the TSF and evaporation pond wall designs to prevent overtopping;
   b. The TSF and evaporation pond walls will be engineered to hold the full capacity of the tailings / RO brine and a significant rainfall event;
   c. The TSF and evaporation pond walls will be engineered and constructed according to specifications;
   d. The integrity of the TSF and evaporation pond walls will be assessed during regular inspections;
   e. The following controls will be implemented to minimise the risk of impact from unintentional tailings or saline water pipeline spills:
      i. Pipelines will be fitted with leak detection;
      ii. Water flows will be shut off if leaks are detected;
      iii. Pipelines will be inspected regularly, especially during extreme heat or fire events;
      iv. Pipelines will be located off access road surfaces;
      v. If pipelines have to cross access roads then they will be buried;
      vi. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence;
   f. The quality of groundwater around the TSF and evaporation ponds will be monitored and cut-off bores will be installed if mounding is greater than predicted;
   g. Sewage will be treated and discharged to a dedicated irrigation area that is appropriately sized for the predicted volumes;
   h. The landfill will be developed and operated in accordance with the Environmental Protection (Rural Landfill) Regulations (Government of WA, 2002);
2. **Obtain and comply with a Mining Proposal issued under the Mining Act.** A MP will be required for the Proposal, for all works apart from minor works that may occur within MRWA tenure. The MP is the primary mechanism for ensuring the design of the TSF and

evaporation ponds are safe and stable, such that the risk of embankment breaches and overtopping is minimised. The MP will ensure that the following mitigation measures are implemented at a minimum:
   a. A Detailed TSF Design Report is approved prior to construction;
   b. A TSF Operating Manual is approved prior to operation;
   c. Geotechnical stability standards are met;
   d. Geotechnical monitoring and inspections are conducted; and
   e. Mitigation measures previously listed in item 1 (for Works Approval and Licences);
3. **Implement the following measures to minimise the risk and impact of hydrocarbon spills:**
   a. Hydrocarbons will be stored either within a bunded area or within self-bunded tanks;
   b. All spills will be controlled, contained and cleaned up as soon as practicable;
   c. Service vehicles will be fitted with spill kits;
   d. Spill kits will be located at all workshop and fuel storage areas;
   e. Environmental incident recording, investigation and reporting system; and
4. **All road surface water crossings will be designed to minimise the potential for erosion.** Haul Road crossings will be constructed as per the recommendations in GRM (2020a; Appendix 8.1) and by adopting the principles from 'Field guide for erosion and sediment control maintenance practices' (NSW Environment and Heritage, 2012).

8.6.3 Rehabilitate

At the completion of the Proposal the site will be rehabilitated to reinstate native vegetation. Key rehabilitation measures are summarised below:

1. Rocky and blocky material from laterite/limonite deposits, and topsoils will be retained separately from other subsoil materials and used for erosion protection during rehabilitation;
2. All disturbance areas (except mine pits) will be landformed to slopes consistent with surrounding landforms, respread with topsoil and rehabilitated;
3. Saprolite materials will not be used as the outer surface for built structures;
4. Rehabilitation slopes above ten degrees will be sheeted with competent materials to provide erosion protection based on erosion testwork and modelling of representative topsoils;
5. Rehabilitation areas will be seeded with local native species; and
6. Research will be conducted into how to establish and maintain conservation significant species in site rehabilitation.

An interim MCP has been prepared to accompany this ERD (Appendix 4) which was developed according to DMIRS Guidelines (2020a; 2020b). The MCP describes the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase including**:**

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks for the TSF and evaporation ponds domains; and
- Completion criteria, monitoring and reporting during closure.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to the construction of the Proposal and will be reviewed and revised every three years.

8.7 PREDICTED OUTCOME

The EPA's environmental objective for this factor is "to maintain the quality of land and soils so that environmental values are protected" (EPA, 2016l). In the context of this objective: "terrestrial environmental quality" is defined as the chemical, physical, biological and aesthetic characteristics of soils (EPA, 2016l). The specific environmental values to be protected are 'the ecosystem health values that the soils support, including biodiversity and seed banks'.

The Proposal is not expected to significantly impact terrestrial environmental quality. Tailings seepage is benign and fresh, and there is saline - hypersaline groundwater throughout the Mine DE and no beneficial users of this resource. Seepage from the TSF and evaporation ponds is not predicted to impact soils other than directly below the infrastructure and leaks and spills of tailings or saline water are able to be managed such that impacts are rare and restricted in extent if they were to occur. Erosion and hydrocarbon spills are able to be mitigated such that significant impacts are unlikely.

The key risks to terrestrial environmental quality is pollution from the Process Plant, TSF, RO Plant, evaporation ponds, saline water pipelines, wastewater treatment plant and landfill. The design and operation of all of these items will be regulated under Part V of the EP Act and the Mining Act.

The implementation of design and operations mitigation measures, and regulation under Part V of the EP Act and the Mining Act, are expected to ensure that the Proposal does not significantly impact this factor. The EPA objective for this factor is therefore able to be met.

9 INLAND WATERS

9.1 EPA Objective

The EPA Objective for this key environmental factor is to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.

9.2 Policy and Guidance

Relevant EPA guidance documents for this factor are listed below:

- Statement of Environmental Principles, Factors and Objectives (EPA, 2020a);
- Environmental Factor Guideline for Inland Waters (EPA, 2018a);
- EIA (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA, 2016a);
- EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2020c); and
- WA Environmental Offsets Guidelines (EPA, 2014).

Other Policy and Guidance for documents for this factor are listed below:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Commonwealth of Australia, online resource, 2018); and
- WA Water in Mining Guideline. Water licensing delivery report series. Report No. 12. (DoW, 2013).

9.3 Receiving Environment

The section below has been sourced from the following reports, provided in Appendix 8:

- Medcalf Project Water Supply Desk Study (GRM, 2015);
- Groundwater Supply Investigation (GRM, 2020a);
- Medcalf Hydrogeological and Hydrological Study: Surface Water Assessment (GRM, 2020b);
- Medcalf Hydrogeological and Hydrological Study: Characterisation of *Marianthus aquilonaris* Habitat (GRM, 2020c); and
- Medcalf Vanadium Project – Haul Road Water Supply (GRM, 2020d).

9.3.1 Survey Effort

Surface Water

Surface water assessment has been informed by 1 m contour data and high resolution aerial imagery supplied by Audalia and regional topographic and satellite imagery data, supplied by Geoscience Australia.

Field work focused on two key areas:

- Defining the surface water hydrology for the haul road catchments; and
- Defining local surface water hydrology (micro-hydrology) in the mining area – particularly around the populations of *M. aquilonaris*.

GRM (2020b) undertook a surface water assessment to identify drainage lines and likely road crossing designs. GRM completed a data collation and review, site visit and characterisation that included sourcing up to date geology maps, groundwater data, contour data, and drainage maps.

A site visit was undertaken on 29 - 30 November 2018 to inform the assessment of drainage for the haul road.

Marianthus aquilonaris Micro-hydrology

A micro-hydrological assessment was conducted to characterise the hydrology of the *M. aquilonaris* sub-populations in proximity to the Proposal. As part of this assessment, a field survey was undertaken by Mr Richard Toll (GRM Senior Hydrogeologist). The *M. aquilonaris* sub-populations visited are shown in Figure 110 (GRM, 2020c). Surface water drainage around the sub-populations (inclusion of all catchment areas with sub-populations) necessarily included the mining areas.

Desktop Groundwater Assessment

A desktop assessment (GRM, 2015) at scoping level was carried out to assess water supply options within the Proposal tenements and in the broader region. The assessment considered the geology and hydrology of the region in relation to water supply resources. Palaeo-valleys were mapped and reviewed along with existing bore and aquifer records which resulted in four supply options:

1. Fractured rock borefield located on-tenement;
2. Palaeochannel borefield in the palaeo-tributary off-tenement;
3. Palaeochannel borefield in the main trunk of the palaeochannel off-tenement; and
4. Negotiate with the current proponents of the Lake Johnston nickel mine to access dewatering surplus.

Groundwater Field Surveys

Field work focused on assessing target areas for water supply. GRM (2020a) undertook the initial groundwater supply field surveys based on the information gained during the desktop assessment. Based on the desktop assessment 14 of 29 targets were drilled between 10 September and 12 October 2019, along with nine monitoring bores that were used to determine groundwater levels and to facilitate stygofauna sampling.

Figure 105 shows the locations of the groundwater bores drilled as part of the GRM programme.

Groundwater quality was determined for groundwater samples collected from selected drill-holes and submitted to SGS Environmental for laboratory analysis. The samples were collected at the end of drilling, with the exception of MWH003 from which a sample was collected from the sand aquifer and the underlying weathered basement. The samples were collected in laboratory supplied bottles, field filtered for metals, and stored in a chilled esky prior to submission the laboratory.

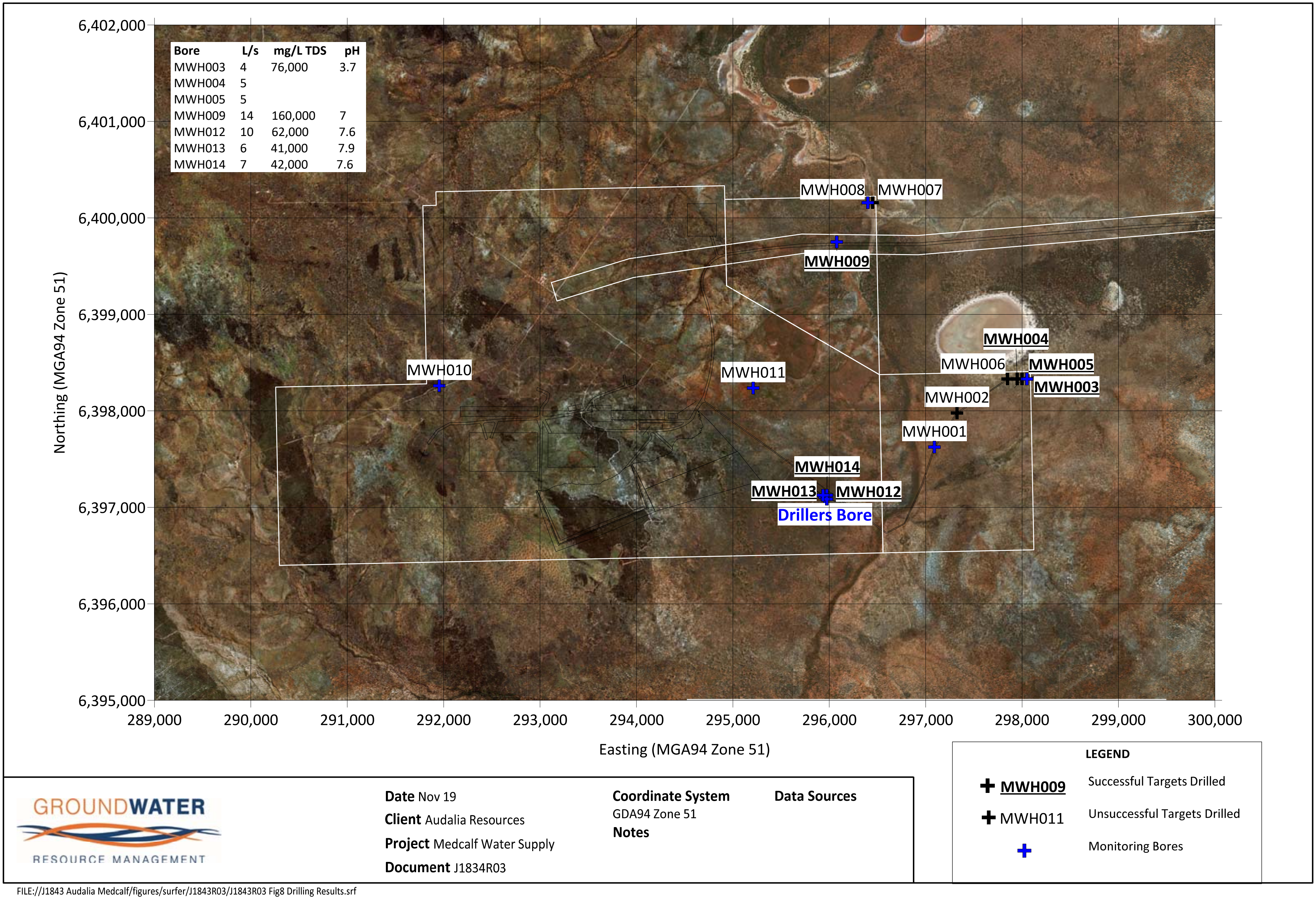


Figure 105: Groundwater Investigation Bore Locations

9.3.2 Climate

The Proposal is located in an area where the climate is classified as 'Hot dry summer, cold winter' based on temperature-humidity classification. Under the modified Köppen system (which uses vegetation) (BoM, 2020) the area is classified as Grassland, warm (persistently dry). Summers are warm to hot and winters mild. Whilst annual rainfall is winter dominant, rain may occur at any time of year.

The nearest rainfall records are available from Norseman and Salmon Gums. Average annual rainfall at Norseman is reported as 293.6 mm/yr, whilst Salmon Gums is 341.2 mm/yr (BoM, 2020). Some sporadic rainfall records were taken by DPIRD but have not been published (I Foster Pers. Comm.). Annual rainfall within the Mine DE is estimated to be around 289 mm/yr (GRM, 2020a).

A number of daily events exceeding 120 mm (the 1% Annual Exceedance Probability) have been recorded in the 86 years of record at Salmon Gums. This indicates that rainfall is variable and large rainfall events may occur at the Proposal. Large rainfall events tend to occur in summer, mainly January to March. However significant events have occurred in September to December and in June.

Average annual relative humidity is 60% with 7 - 8 hours of sunshine per day (HTTP://WWW.BOM.GOV.AU/JSP/NCC/CLIMATE_AVERAGES). Mean annual pan evaporation is about 1,500 mm/year. Mean monthly evaporation exceeds mean rainfall in every month of the year, however, evaporation rates are much lower in winter than in summer. This pattern of variation in evaporation combined with rainfall distributed during the year in variable falls suggests that the soil profile prior to larger events is likely to be relatively dry in summer but is likely to be moist to saturated in winter, meaning a similar rainfall intensity event would likely result in a larger proportion of runoff toward the end of winter than during the drier months over summer and autumn.

9.3.3 Surface water

Neither the Mine DE nor the Haul Road DE are within areas that are proclaimed surface water areas (to protect water quality for water supply) under the RIWI Act (as accessed on 5 May 2020) (https://www.water.wa.gov.au/__data/assets/pdf_file/0004/1669/86306.pdf). None of the surface water catchments within the DE's drain into conservation estate, freehold land or other tenure held by other potential water users.

Geology, land systems, soils and runoff

The surface geology for the area including the Haul Road and Mine DEs is shown in Figure 106. This data set is supplemented by observations made on site (map of mine area geology is shown in Figure 106). A full description of the geology is provided in Section 8 (Terrestrial Environmental Quality). In summary, the surface geology features relevant to surface water are:

- Two main surface geologies are traversed along the Haul Road DE:
    - Colluvium at the eastern and western extremities. Soils on colluvium tend to be clay loams and will produce some runoff, at least in intense rainfall events. Some defined drainage lines cross the road;

    - Sandplain occurs in gently undulating landforms through the middle of the road alignment. Soils here are sandy loams and probably produce little runoff; and
- The Mine DE is within a band of low hills that are characterised by rocky outcrops, shallow stony soils, and steeper slopes. To the north and south of the hills is mapped as colluvium. With distance downslope the depth of soil increases into the colluvial zone.

Vegetation and Runoff

There is largely undisturbed native vegetation through the entire Mine and Haul Road DE's. Vegetation through the mine site and along the haul road is generally classified as Eucalypt and Mallee woodlands and shrublands. The native vegetation is relatively intact and generally rated as being in good or very good condition (Botanica, 2020c). Landforms covered with native vegetation generate less runoff than equivalent landforms that have been cleared for agriculture.

Vegetation across the area is variably affected by fire. At any one time, the vegetation will include areas in various stages of regrowth and with variable amounts of accumulated leaf litter and fallen material. The recent fire history affects the short-term hydrological characteristics of the landscape (GRM, 2020b). Areas with little vegetation and ground cover (i.e. freshly burnt) will have higher rates of runoff and increased turbidity compared with heavily vegetated areas.

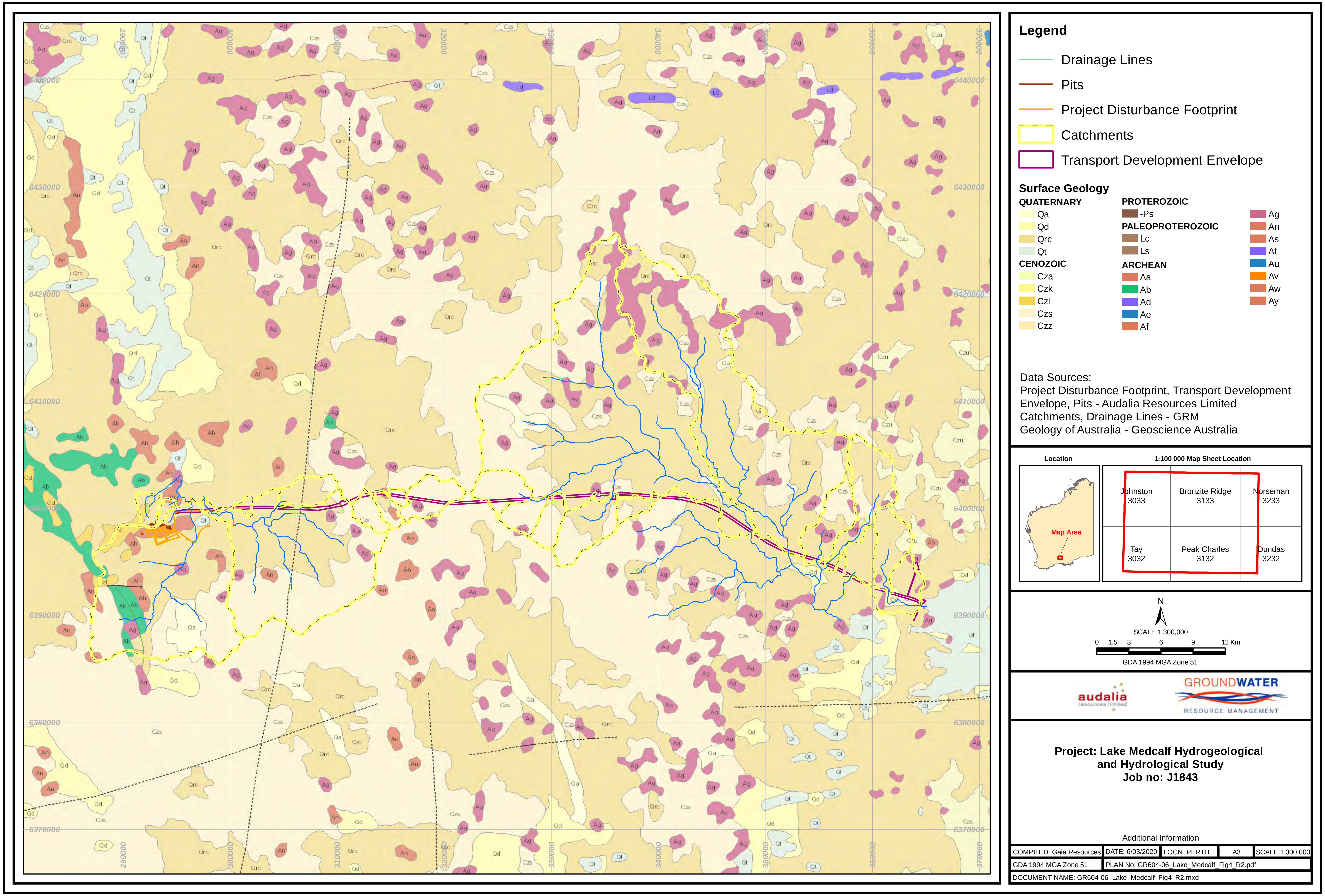


Figure 106: Regional surface geology

Haul Road Hydrology

The region is characterised by subdued topography with generally small to moderate sized catchments with poorly defined water courses that either dissipate in flat areas or flow into lake systems. The lake systems are saline and mirror old paleo-drainage lines that form the major drainage feature of the region. The lakes are generally underlain by hypersaline groundwater systems. The drainage lines often dissipate on flat ground before reaching another tributary, or drain towards a small salt lake named Lake Medcalf, larger Lake Johnston, Lake Gilmore in the east or un-named salt lakes near Lake Gilmore.

There are no gauging or water sampling stations for any of the lakes or watercourses within the immediate area. No water quality or flow data is therefore available.

The topography along the haul road alignment is largely flat, with isolated low granite outcrops and sandy rises. Elevations are generally in the range of 250 - 350 m RL. Drainage is generally subdued, with the colluvium and sandy soils through the mid-section of the Haul Road DE being quite flat. A series of un-named water courses are evident at both the western and eastern ends of the Haul Road Study Area. The topography is more undulating at the eastern and western ends. The watercourses either dissipate on flat ground, or report to local salt lakes. At the eastern end of the Haul Road Study Area, they generally report to a small salt lake to the west of Lake Gilmore (on the other side of the Coolgardie-Esperance Highway). At the western end they report to Lake Johnston (about 25 km north of the watercourse crossing, or Lake Medcalf (about 3 km north of the watercourse crossing).

Catchments for drainage lines crossing the Haul Road DE and potential crossing locations are delineated in Figure 107. The haul road intersects 22 catchments with a total catchment area of 1,077 km^2. The catchment characteristics are summarised in Table 61. Note that catchments 1 and 2 occur within the Mine DE and are discussed in the following section. Also note that the Mine DE has also used the same numerical system for naming catchments that are within the Haul Road DE.

Table 61: Catchments of watercourses that intersect with the Haul Road Study Area

Catchment No.	Area (km^2)	Description
3	162.6	Drains the southern portion of the Mine DE. Drained by a tributary of Lake Medcalf that crosses the haul road just east of the Mine DE at Crossing 1.
4	148.0	Large catchment. Drains toward Lake Medcalf. Includes a number of internally drained areas discharging to small playas. A diffuse drainage line crosses the haul road at Crossing 2.
5	2.0	Small catchment with no defined drainage line at the haul road.
6	12.0	Small catchment with a diffuse drainage line at the haul road.
7	7.5	Small catchment with no defined drainage line at the haul road.
8	5.6	Small catchment with a diffuse drainage line at the haul road. Drainage line is the upper reaches of a stream discharging to Lake Medcalf.
9	2.2	Small catchment with no defined drainage line at the haul road.
10	15.7	Small catchment with a diffuse drainage across the haul road. Topographic data indicates a number of potential drainage valleys or low points (Crossings 9 - 11).
11	15.0	Small catchment with a diffuse drainage line at the haul road. Several potential crossings or low points at the haul road (Crossings 12 and 13).

Catchment No.	Area (km^2)	Description
12	9.8	Small catchment with a diffuse drainage line at the haul road.
13	10.0	Small catchment with no defined drainage line at the haul road.
14	23.8	Moderate sized catchment with no defined drainage line at the haul road.
15	6.1	Small catchment with no defined drainage line at the haul road.
16	316.5	Large catchment with a drainage valley at the haul road but ill-defined stream channel. Number of crossings in this area. The main drainage line is at Crossing 21.
17	230.7	Large catchment with a diffuse drainage line at the haul road.
18	22.4	Moderate sized catchment with a diffuse drainage line at the haul road.
19	31.9	Moderate sized catchment with a diffuse drainage line at the haul road.
20	11.2	Small catchment with no defined drainage line at the haul road.
21	19.2	Small catchment with a drainage valley or upper reaches of a playa at the haul road. Drainage line crosses the road alignment at Crossing 26.
22	16.6	Small catchment with a number of ill-defined crossings of the haul road (Crossing 27 and 28). Receives streamflow from Catchment 21 and includes a number of playas in the lower reaches. Any discharge from the playas is across the Coolgardie Esperance Highway to Lake Gilmore.
Total	**1,077**	**Generally small to moderate sized catchments with poorly defined water courses that either dissipate in flat areas or flow into lake systems.**

Shallow overland flow could occur in flatter areas along the road alignment. Indicative areas where overland flow have been identified by GRM (2020a) to generally occur in the mid and eastern sections of the Haul Road Study Areas shown in Figure 108.

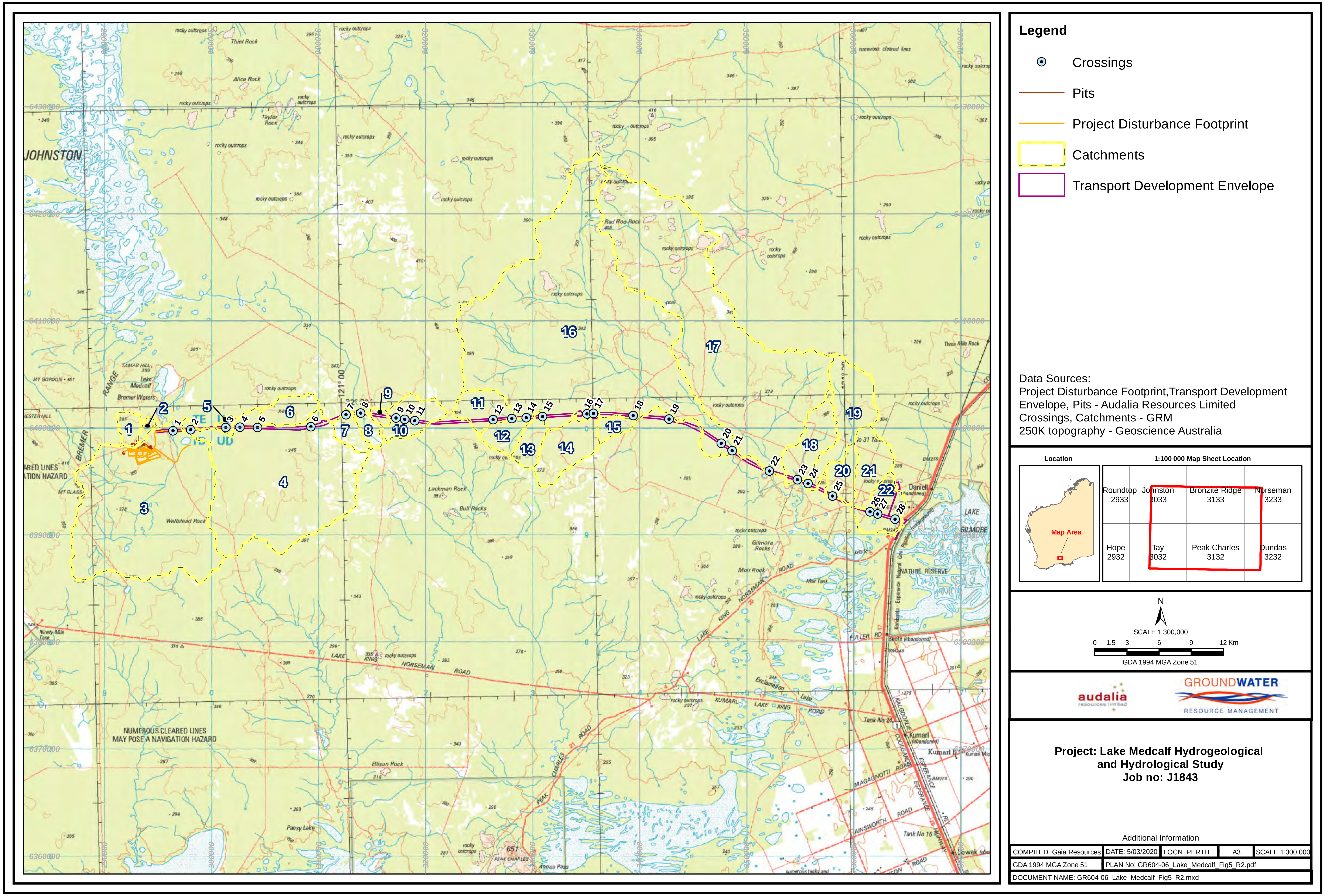


Figure 107: Haul road catchments and drainage lines (GRM, 2020a).

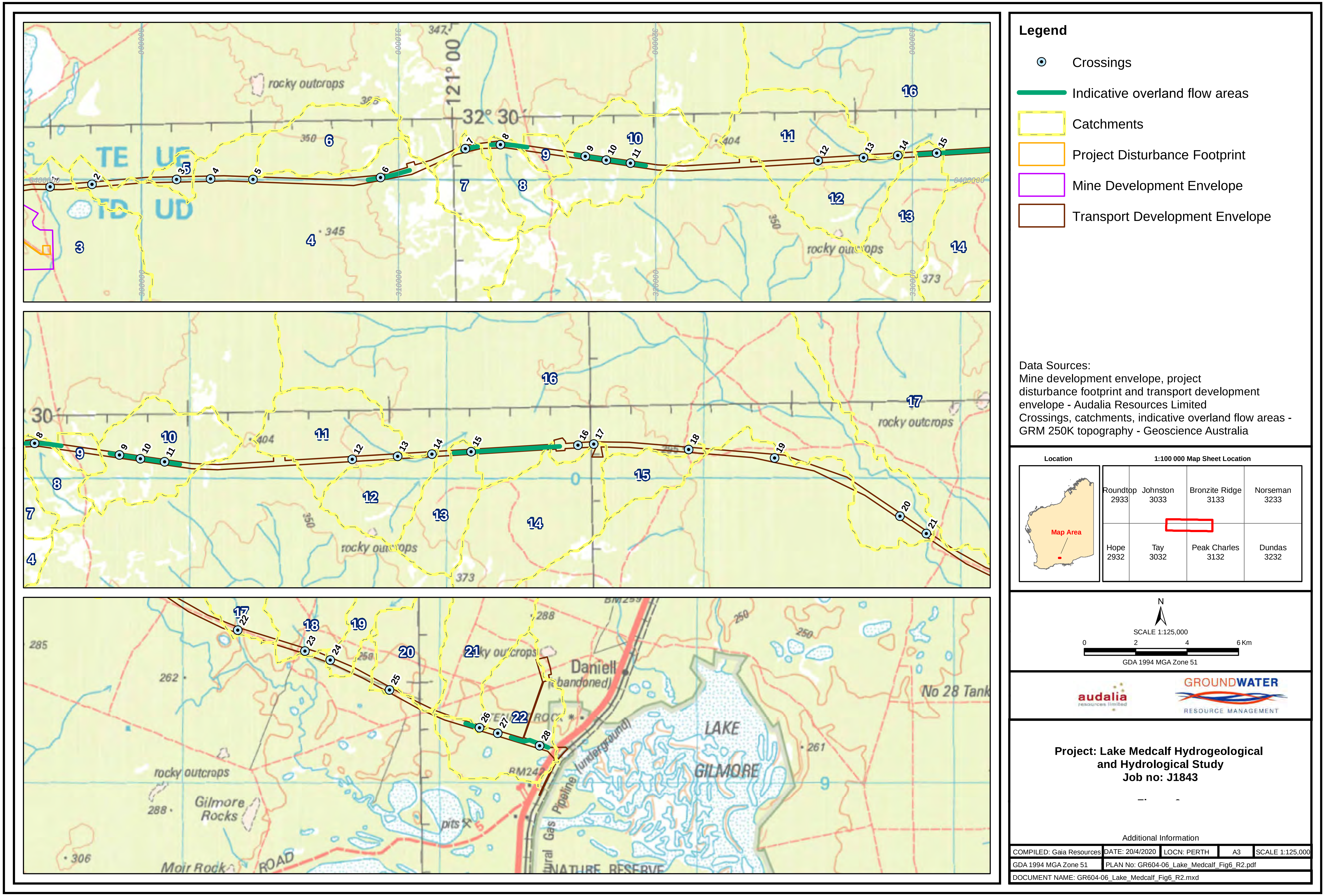


Figure 108: Indicative overland flow for the haul road (GRM, 2020a).

Mine Site Hydrology

Drainage through the Mine Study Area is defined by a line of low hills trending in an east-west direction. Drainage from the hills through the Mine Study Area is generally either toward the north or south.

The northern side of the range of hills provides northerly-draining catchments that drain into Lake Medcalf (Figure 107) located about 3 - 4 km to the north of the Mine Study Area. Slopes in drainage lines are generally around two degrees. Drainage lines are evident and some soil erosion is noted to occur in erodible soil types.

The southern side of the range of hills provides southerly-draining catchments that also (ultimately) drain into Lake Medcalf via a tributary that crosses the haul road before joining Lake Medcalf from the south.

The landscape is characterised by rocky hill tops grading to deeper loamy soils with distance downslope (Western Horticultural Consulting, 2019). Rock is generally exposed on or near the top of the hills, forming a surface that is likely to generate higher levels of runoff. In smaller events, most runoff will reinfiltrate in areas downstream with a deeper soil profile.

Defined streamlines form toward the bottom of the catchments. Runoff from the deeper soil areas will occur in more intense events and move as overland flow concentrating into drainage lines then defined streams as flow rates increase with distance downstream. Vegetation density increases as the soil profile depth increases and in proximity to drainage lines (GRM, 2020c).

Figure 109 shows the sub-catchments and drainage flow lines within the mine area. Main catchments within the Mine DE are delineated in Figure 107 and the catchment characteristics are summarised in Table 62.

Table 62: Catchments that intersect with the Mine DE

Catchment No.	Catchment Area (km^2)	Description
1	5.9	Drains the north western portion of the mine site. Discharges toward Lake Medcalf
2	2.0	Drains the north western portion of the mine site. Discharges toward Lake Medcalf
3	162.6	Drains the southern portion of the Mine DE. Drained by a tributary of Lake Medcalf that crosses the haul road just east of the Mine DE at Crossing 1

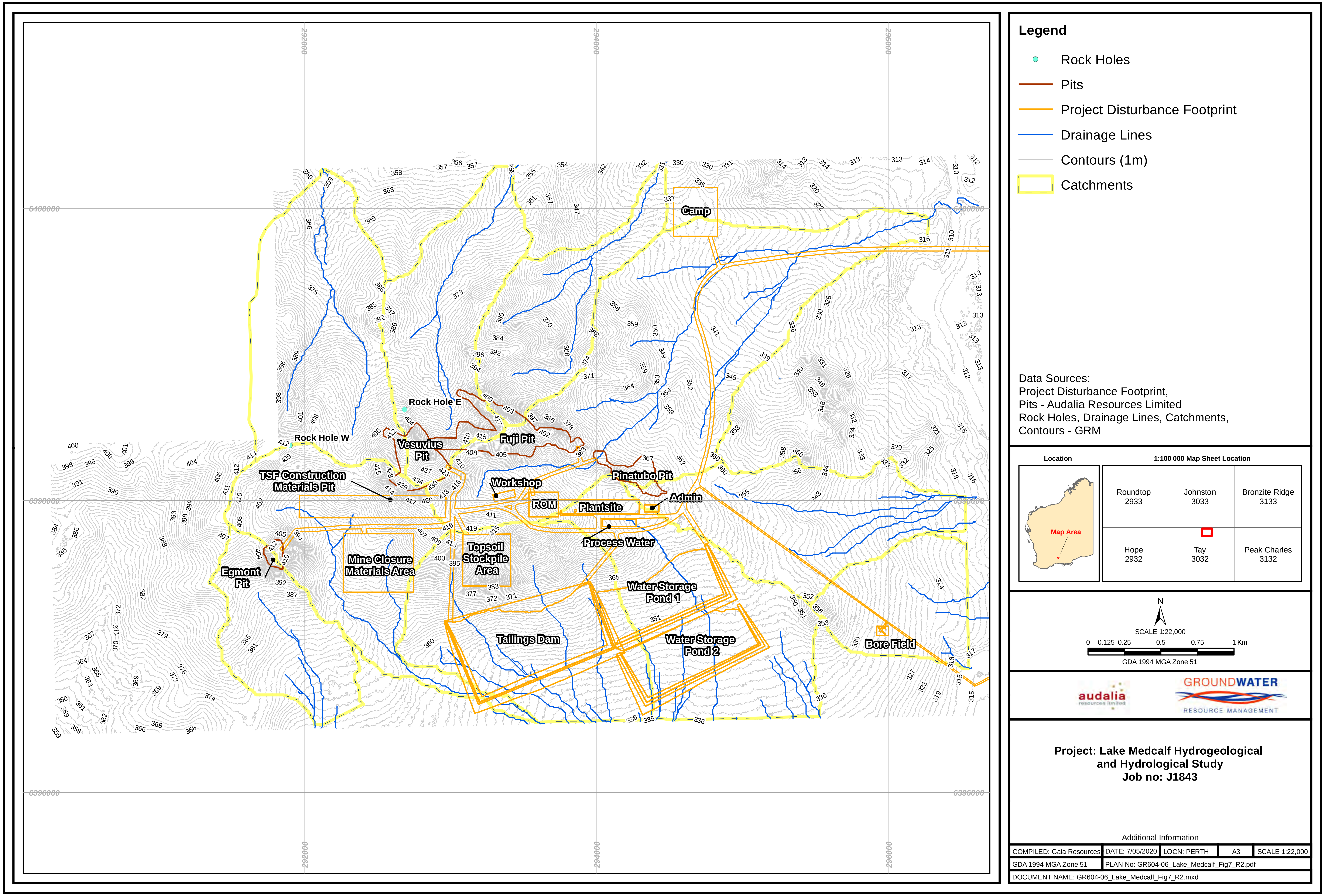


Figure 109: Hydrology of the Mine DE

9.3.4 Hydrological Characterisation of *M. aquilonaris* Habitat

A number of comprehensive studies of the distribution and characteristics of *M. aquilonaris* populations have been commissioned by Audalia – these are detailed in Section 5. This section provides a review of the hydrological characteristics of *M. aquilonaris* habitat, including the physical environment relevant to hydrology.

Of 13 discrete areas of the soil shallow gravel over indurated mottled zone, five are occupied by *M. aquilonaris* populations (Figure 109). None of those five occupied habitats are fully occupied (i.e. the population does not entirely cover the shallow gravel over indurated mottled zone). Conversely, *M. aquilonaris* has not been located as currently growing outside of shallow gravel over indurated mottled zone (noting a single historic record occurs outside this soil type but no is longer present in this location).

The areas that contain current *M. aquilonaris* sub-populations all lie across ridge lines and down north-east or north-west trending slopes. Of the areas of shallow gravel over indurated mottled zone without *M. aquilonaris* populations, most lie on ridgelines and on slopes with aspects ranging from northerly to southerly. One lies mid-slope. One lies in the upper reaches of a small drainage line.

Modelling indicates that all of the mapped soil areas have a high runoff rate, which is consistent with their shallow soil profile and rocky surface (refer section 5). All of the areas receive some runoff from upslope with the amount varying depending on the location in the landscape, local topography and surrounding soils. The modelled water balance is dominated by evapotranspiration, which accounts for 60 - 80% of rainfall. This means that most of the rainfall is taken up by plants and transpired or evaporated from soil, rock and vegetation surfaces.

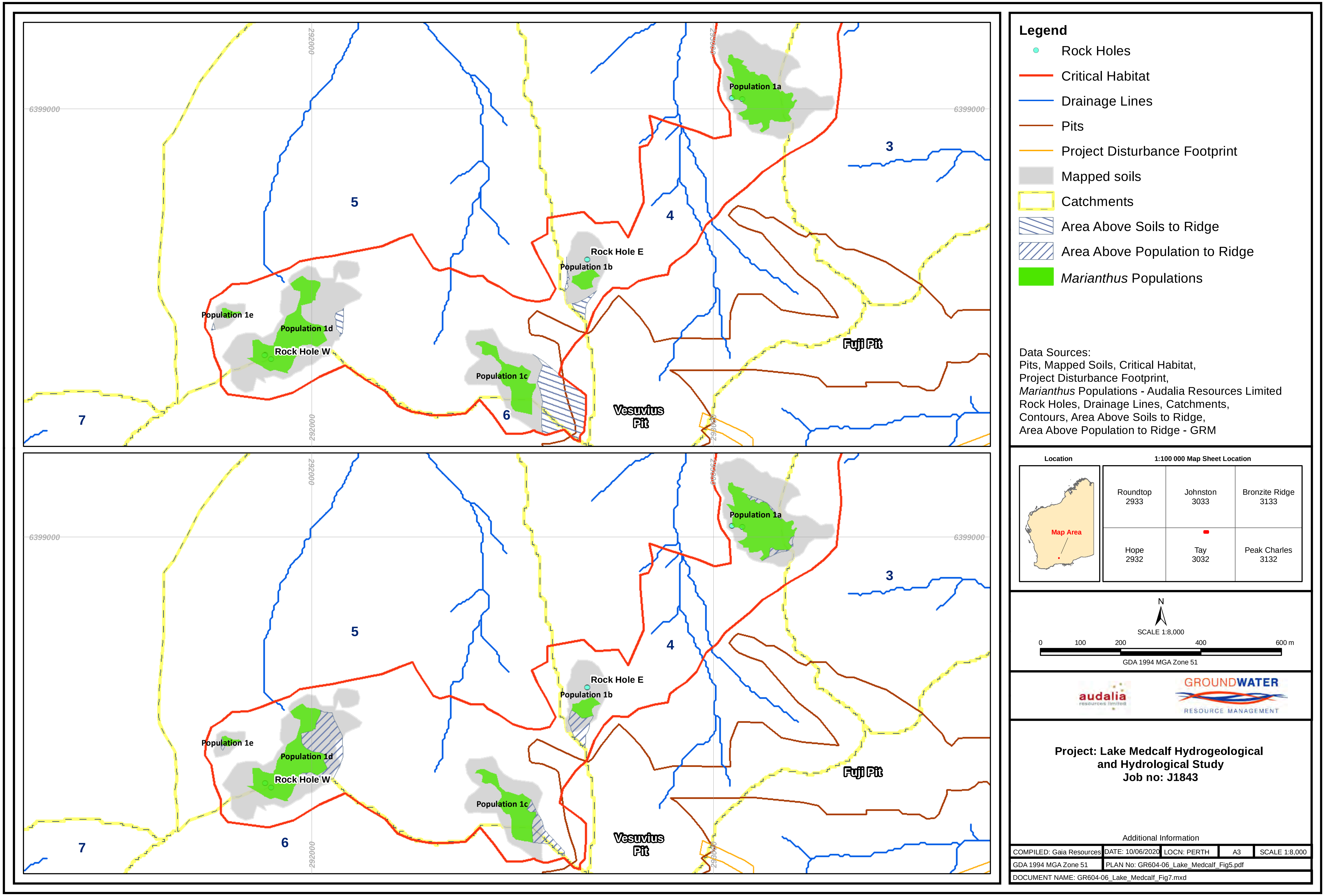


Figure 110: M. aquilonaris sub-populations, shallow gravel over indurated mottled zone and catchment areas

Catchment Characteristics

GRM (2020c) defined the catchments surrounding the *M. aquilonaris* populations and these are shown in Figure 111. Catchments 1, 2 and 7 are not host to any sub-population of *M. aquilonaris*. Catchments 3 - 6 are larger catchments that all host sub-populations with catchments 4 and 5 hosting the majority of plants (sub-populations 1a, 1b, 1c, and 1d). The total area of catchments that contain *M. aquilonaris* is 342.3 ha and the area of each catchment is provided in Table 63.

Table 63: Catchment areas in proximity to *M. aquilonaris* populations

Catchment No.	Description	Area (ha)
1	Small catchment drains north with no *M. aquilonaris.*	9.3
2	Small catchment drains north with no *M. aquilonaris.*	15.1
3	Moderate catchment drains to north east. Contains part of sub-population 1a.	74.8
4	Large catchment drains north. Contains majority of sub-population 1a and all of 1b	121.7
5	Moderate catchment drains north. Contains most of sub-population 1d and likely includes 1e	81.2
6	Moderate catchment drains south and then east. Contains a small portion of sub-population 1d	64.6
7	Large catchment that drains south-west with no *M. aquilonaris*	63.1
	Total	**429.8**

All of the sub-populations are located at or close to the divide (top) of the catchments in which they occur. The catchment drainage lines only become clear as the drainage coalesces further down the catchment.

M. aquilonaris populations are located high in the landscape where they have minimal catchment above the population (Table 64). Areas of catchment above the populations range from 0.02 - 1.35 ha. The areas of occupancy of all current populations range from 0.2 - 1.71 ha. Below the populations however, catchment areas range from 65.28 - 121.34 ha. This means that the proportion of the catchments that are above the populations ranges from 0.03 – 1.4%.

Table 64: Proportion of catchment above and below *M. aquilonaris* sub-populations

Catchment	Catchment area (ha)	Optimal habitat area within catchment (ha) *a*	Catchment area above Optimal Habitat (ha)	Catchment area below Optimal Habitat (ha)	Population area of occupancy (ha) *b*	Catchment area above area of occupancy (ha)	Catchment area below population (ha)
1	9.3	-	-	-	-	-	-
2	15.1	-	-	-	-	-	-
3	74.9	1.03	0	73.87	0.2	0.02	74.84
4	121.7	4.67	0.14	116.86	1.71	0.39	121.34
5	94.8	6.78	1.50	86.35	1.28	1.35	93.45
6	65.4	1.56	0.19	63.65	0.30	0.08	65.28
7	63.1	-	-	-	-	-	-

a = area of mapped shallow gravel over indurated mottled zone soils; b = area of *M. aquilonaris* population

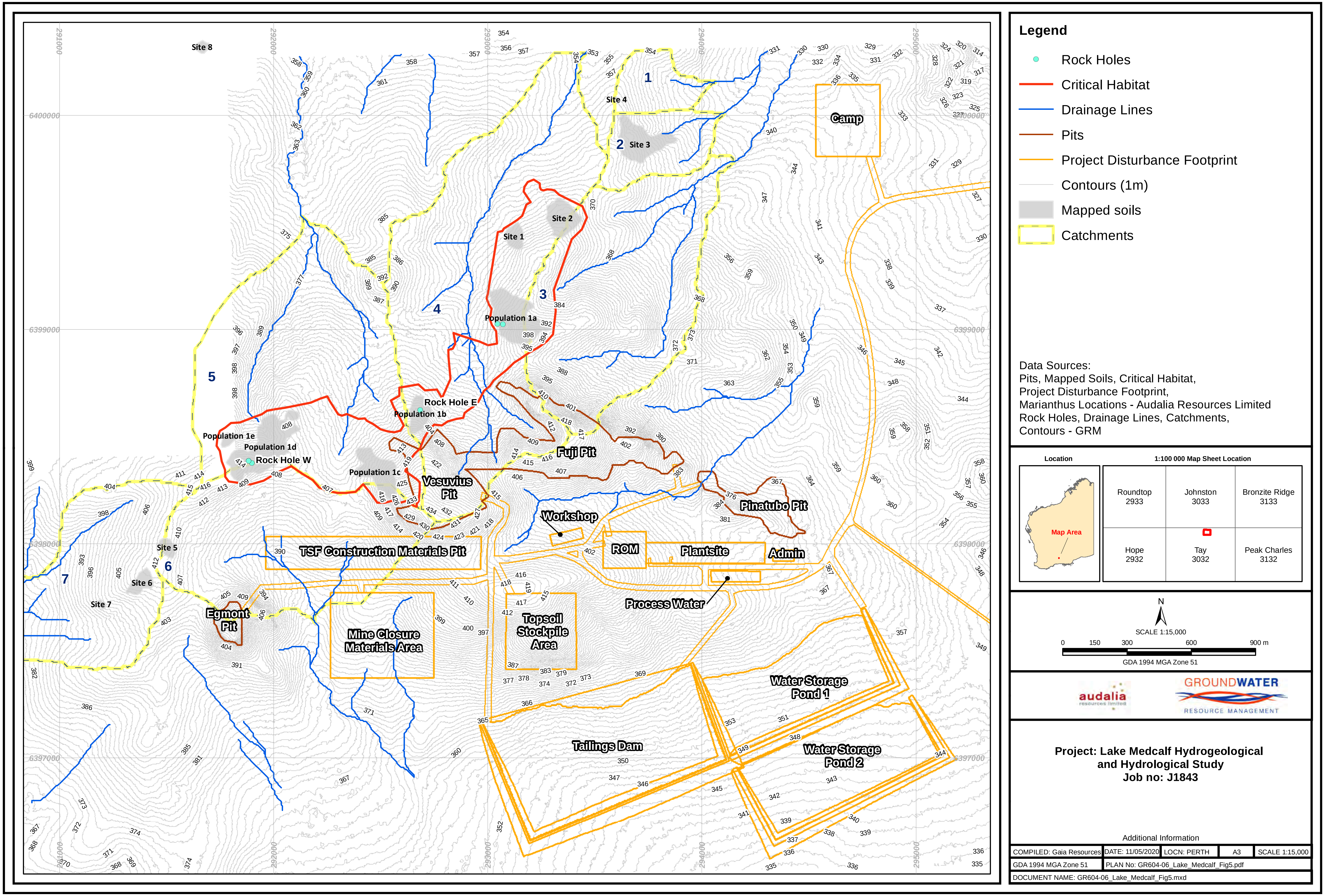


Figure 111: Sub-catchments and drainage lines relevant to M. aquilonaris sub-populations

Conceptual Catchment Water Balance

GRM (2020c) prepared a simple water balance model for the soil type (the shallow gravel over indurated mottled zone) that hosts the *M. aquilonaris* populations. The model was run based on site rainfall records for the period 2014 - 2017. Average rainfall over this period was 390 mm/year. Table 65 presents the water balance results. The water balance is dominated by evapotranspiration, which accounts for 97% of rainfall. This means that most rainfall is taken up by plants and transpired or evaporated from soil, rock and vegetation surfaces (GRM, 2020a).

The amount of runoff leaving the catchments via drainage lines is relatively low, predicted to be 3% of average annual rainfall for the total area. While runoff rates from upper rocky areas is predicted to be high, it is apparent from site observations that runoff water generated from the upper slopes is also infiltrated into the colluvial zone downstream.

Total seepage below the root zone, which could recharge groundwater, is not predicted based on the model. This observation is consistent with the depth to groundwater (40 - 60 m in this area), however, no monitoring bores are installed within the *M. aquilonaris* populations that would allow direct observations to be made. Recharge is likely to occur, and be episodic, mostly occurring during extended wet periods or resulting from significant rainfall events. Accordingly, wetter periods than observed during the simulation period (2014 - 2017) would be expected to generate seepage.

Table 65 also shows the predicted runoff from upslope of each of the modelled *M. aquilonaris* sub-populations based on the catchments above them and a typical 390 mm/yr rainfall. The model predicts run-off from upslope of each sub-population individually, and due to different amounts of upslope catchment, results in estimates ranging from 7 - 84 mm/yr for the modelled weather period (2014 - 2017). The model also predicts evapotranspiration (plant water and soil water loss via evaporation) to range from 62 - 82% of rainfall. No seepage below the root zone was predicted at any of the sites. Areas are shown on Figure 111.

Table 65: Predicted soil area water balance (from GRM, 2020c)

Area	Inflows (mm/year)	Area water balance (mm/year)		Area water balance (% of rainfall + runoff inflow)	
	Runoff from upslope	Evapo-transpiration	Runoff leaving the area	Evapo-transpiration	Runoff leaving the area
Sub-population 1a	10	321	74	81	19
Sub-population 1b	34	322	97	76	24
Sub-population 1c	84	322	147	63	37
Sub-population 1d	7	321	71	82	18
Site 1	63	327	121	70	30
Site 2	17	321	81	80	20
Site 3	86	322	150	63	37
Site 4	39	367	68	83	17
Site 5	10	331	66	84	16
Site 6	14	331	71	82	18

Area	Inflows (mm/year)	Area water balance (mm/year)		Area water balance (% of rainfall + runoff inflow)	
	Runoff from upslope	Evapo-transpiration	Runoff leaving the area	Evapo-transpiration	Runoff leaving the area
Site 7	52	336	104	74	26

Notes: Water balance is presented for the unsaturated zone (root zone). Simulation period 2014-2017. Rainfall and evaporation data are for the location of the BoM Salmon Gums station, derived using BoM data drill.

Rock Holes

There are two rock holes (Rock Holes W and E) shown in Figure 111 that are located close to the *M. aquilonaris* sub-populations. These are small cavities in the surface rock that collect rainfall and local streamflow and appear to pond water for a significant time after rainfall. The water appears to be lost mainly to evaporation, but the rock holes have been observed to retain water for long periods after rain (J Williams pers. comm.), which suggests that there may some very shallow (top 10 - 20 cm) accumulation of infiltration that is maintaining water supply. There is no indication as to whether shallow accumulation of infiltration is widespread within the shallow gravel over indurated mottled zone soil type.

The two rock holes were included in the water balance model, as summarised in Table 66, based on a typical 390 mm/yr rainfall. The modelling indicates that inflow to the rock holes comes from direct rainfall and variable overland flow from a small catchment. Rock Hole E appears to have a larger catchment than Rock Hole W. Both holes would readily fill and then overflow in larger events. Water is then lost mainly to evaporation over the following 1 - 2 months.

Table 66: Predicted rock hole water balance (from GRM, 2020c)

Area	Inflow to rock hole (mm/year)	Water balance (mm/year)			Area water balance (% of rainfall + runoff inflow)		
	Runoff inflow from catchment	Evapo-transpiration	Overflow from the rock hole	Seepage below the root zone	Evapo-transpiration	Runoff leaving the catchment	Seepage below the root zone
Rock hole W	341	318	411	0	44	56	0
Rock hole E	811	318	881	0	27	73	0

Notes: Water balance is presented for the rock hole pond. Simulation period – 2014-2017. Rainfall and evaporation data are for the BoM Salmon Gums station, derived using BoM data drill. Pond representation in the model is approximate.

Soil moisture

A detailed soil investigation for the Medcalf site was undertaken by Western Horticultural Consulting (2019). The moisture holding capacity of a soil depends on soil depth, soil texture and the percentage of inert material such as gravel. Deep, well-structured soils allow roots to access water at greater depths in the soil profile. Loams hold more water than sands. Gravels do not hold moisture and a high percentage of this material will limit the soils water holding capacity.

Plant available water stored over the depth of the effective root zone for a typical example of each of the soil types noted around the *M. aquilonaris* sub-populations (Table 67). The figures are derived from a soil moisture calculating spreadsheet developed by DPIRD staff utilised by Western Horticultural Consulting (2019).

The 'Alkaline red shallow loamy duplex' has the highest plant available water within the root zone while the 'Shallow gravel over indurated mottled zone' has a very low plant available water.

Table 67: The estimated effective rooting depth and plant available water for typical examples of the five soil groups

Soil group	Estimated effective rooting depth (cm)	Plant available water(mm)
'Alkaline red shallow loamy duplex'	100	80
'Loamy gravel'	100	40
'Shallow gravel over indurated mottled zone'	15	6
'Stony soils'	30	10
'Shallow gravel'		

In summary, *M. aquilonaris* grows on gravelly, shallow loamy soils with an indurated, mottled zone layer that occurs within 30 cm of the soil surface. The occurrence of the 'shallow gravel over indurated mottled zone' and *M. aquilonaris* sub-populations coincide completely as shown in Figure 109 (i.e. all *M. aquilonaris* sub-populations all occur within shallow gravel over indurated mottled zone).

The study identified indicators of underlying geological structures, such as vughs, iron-stained fracture surfaces, quartz veining and bleached shearing in outcrops adjacent to *M. aquilonaris* communities, which may be of benefit to the *M. aquilonaris* plants, in terms of persistent soil moisture from within discrete fractured bedrock zones underlying the indurated mottled zone soils (Table 68 and Figure 16).

Table 68: *M. aquilonaris* sites visited

Site ID	Observation
1	No observed geological structures.
2	Vughs observed in exposed bedrock.
3	Exposed bedrock bleached, gossaneous, folded. Structure dipping 80° to the north.
4	Exposed bedrock indicates small fault striking north south.
5	Exposed bedrock indicates iron stained fracture.
6	Exposed bedrock gossaneous, quartz rich and folded. Structure dipping 75° to the west north-west.
7	Iron stained fault. Structure dipping 80° to the north north-east.
8	Vughs and shearing observed in exposed bedrock. Structure dipping 70° to the north north-east.
9	Quartz fragments up to 15 cm.
10	Exposed bedrock gossaneous with metamorphosed quartz.
11	Metamorphosed quartz subcrop.
12	Exposed bedrock folded with quartz stringers (0.5 m width), structure dipping 80° to the north.
13	Exposed bedrock bleached, faulted, quartz rich, iron stained and vughy.
14	Shearing and vughs observed in outcrop, shear dipping 85° to the north.

9.3.5 Groundwater

Neither the Mine DE nor the Haul Road DE are within areas that are proclaimed groundwater areas (to protect water quality for water supply) under the RIWI Act (as accessed on 5 May 2020) (https://www.water.wa.gov.au/__data/assets/pdf_file/0019/1675/86307.pdf).

Groundwater investigations conducted by GRM (2020b) have focused on establishing a water supply around the mine area and immediate surrounds. This will be the most significant demand on water supply and is estimated to be 0.8 GL/yr for all processing, potable and mine site dust water supplies.

The following sections on groundwater are from GRM (2020b) unless otherwise noted.

Regional Groundwater

The regional hydrogeological conditions are derived from regional hydrogeological assessments completed by Kern (1995), Commander (1992), and GRM's previous experience in the Lake Johnston greenstone belt. The hydrogeology around the Mine DE is characterised by low relief and north easterly draining palaeo-drainage systems, underlain by Archean sequences.

Groundwater typically occurs in (from deepest to shallowest):

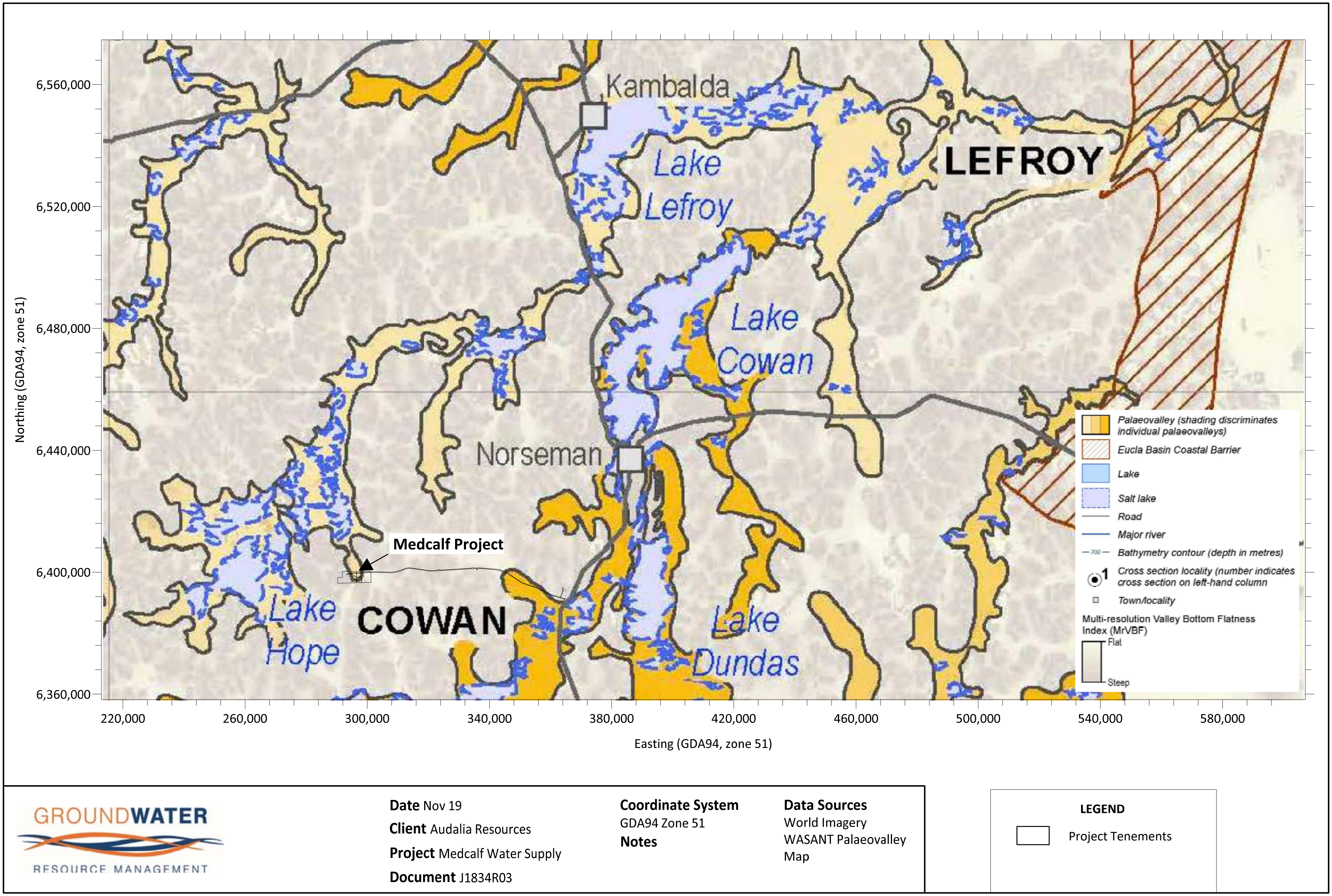
- Regional catchment-controlled flow systems in fractured rock aquifers;
- Tertiary palaeochannel sands; and
- Surficial laterite, alluvium and calcrete.

Groundwater occurrences in fresh bedrock are associated with discrete interconnected fractures in the rock. Fractured bedrock aquifers occur more commonly in mafic, ultramafic and granitic rocks than in sedimentary or felsic volcanic / volcanoclastic units. In contrast the mafic and ultramafic dykes which are prevalent in the region typically form hydraulic barriers to groundwater flow.

Fractured bedrock aquifers in the Lake Johnston area can be high yielding (i.e. up to 100 L/sec when intercepted during underground mining). However, as a result of their discrete nature (i.e. having low storage characteristics), they typically dewater rapidly and consequently may not be reliable as a long term water supply. Permeability in the bedrock away from these features is low, with low storage characteristics.

The Tertiary paleo-drainage systems of the region typically provide the largest source of groundwater in the area. The Mine DE is located at the southern extent of a tributary along the Lefroy palaeo-drainage system (Figure 112), a large north-easterly draining system which once carried surface water to the Eucla Basin. The sedimentary sequence of the Lefroy palaeo-drainage is dominated by the Wollubar Sandstone, a high yielding sequence of quartz sand, with minor conglomerate, silt, clay and lignite. Overlying the Wollubar Sandstone is the Perkollili Shale, which provides a semi-confining layer to the main channel aquifer.

The smallest groundwater source in the area are the groundwater occurrences found in the surficial sediments.



FILE://J1843 Audalia Medcalf/figures/surfer/J1843R03/J1843R03 Fig4 hydrogeology.srf

Figure 112: Regional Hydrogeology (from Kern 1995)

Groundwater Users

The Proposal is located within the Nullarbor Sub-Area of the Nullarbor Groundwater Area. This is an unproclaimed groundwater area and, in accordance with RIWI Act, is not subject to groundwater licensing unless abstraction is from a confined (artesian) or semi-confined aquifer.

A review of the DWER Water Information Resource database was conducted by GRM (2020b) which showed 57 registered bores within 50 km of the Mine DE (Figure 113). The closest registered bores to the Mine DE are a cluster of 34 bores located 37 km south-east of the Mine DE that were drilled in 1929 to depths of between 1 and 49 m. There is a further cluster of similar bores located 46 km south-east of the Mine DE. These bores are all located at least 30 km from the Haul Road DE also (see Figure 113).

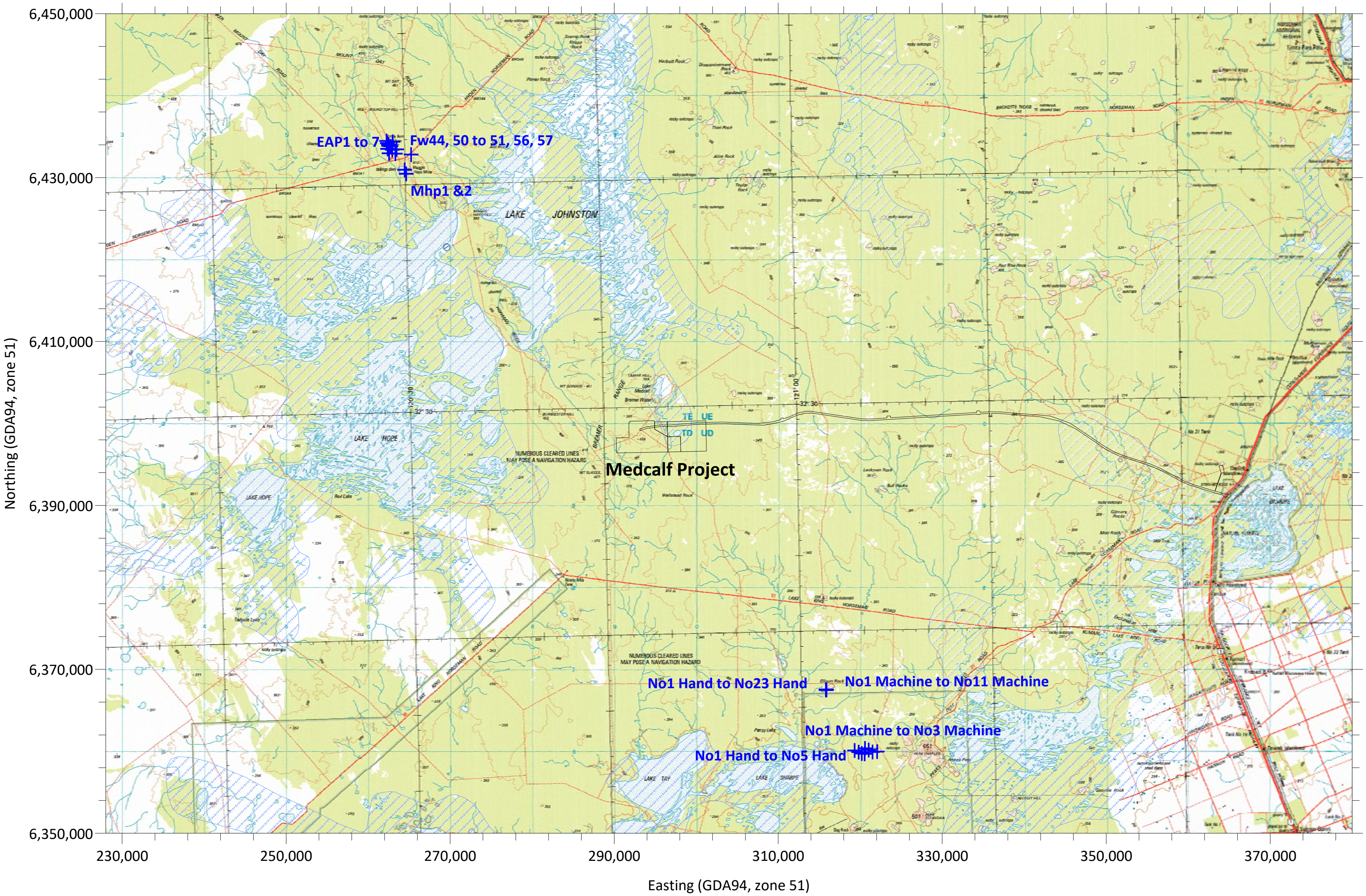
There are no water quality data associated with these bores, which were likely targeting fresh water supplies.

The next closest bores are a series of six bores drilled in 1970 for Amax Exploration Australia and are located 46 km north-west of the Mine DE. These bores are reported as being operational and understood to be the dewatering bores for Poseidon Nickel Limited's Maggie Hays mine within their Lake Johnston Operation, which are currently under care and maintenance. Poseidon Nickel Limited currently hold a licence allocation for 10 GL/yr from the fractured rock groundwater resource. The bores were reportedly low yielding (<1 L/s), to a depth of up to 92 m. Further bores are located 48 km north-west from the Mine DE and were installed in 2000 and understood to be dewatering and water supply bores for Poseidon Nickel Limited's Emily Ann mine within their Lake Johnston Operation.

The DWER online water register was also interrogated to identify the presence of existing licensed groundwater users in the vicinity of the Proposal. The location of existing nearest licensed groundwater users is shown in Figure 114:

- Poseidon Nickel Limited's Maggie Hays mine tenements (described above); and
- Neil Alan Hoey, located 45 km north north-west of the Mine DE for an allocation of 99,000 kL/yr from the fractured rock resource, over tenement M63/549.

Analysis of the yield ranges of regional bores shows a range of yields (Figure 115) with very few bores yielding in excess of 20 L/s. Bores yielding less than 5 L/s are most common.



Date Nov 19
Client Audalia Resources
Project Medcalf Water Supply
Document J1834R03

Coordinate System
GDA94 Zone 51
Notes

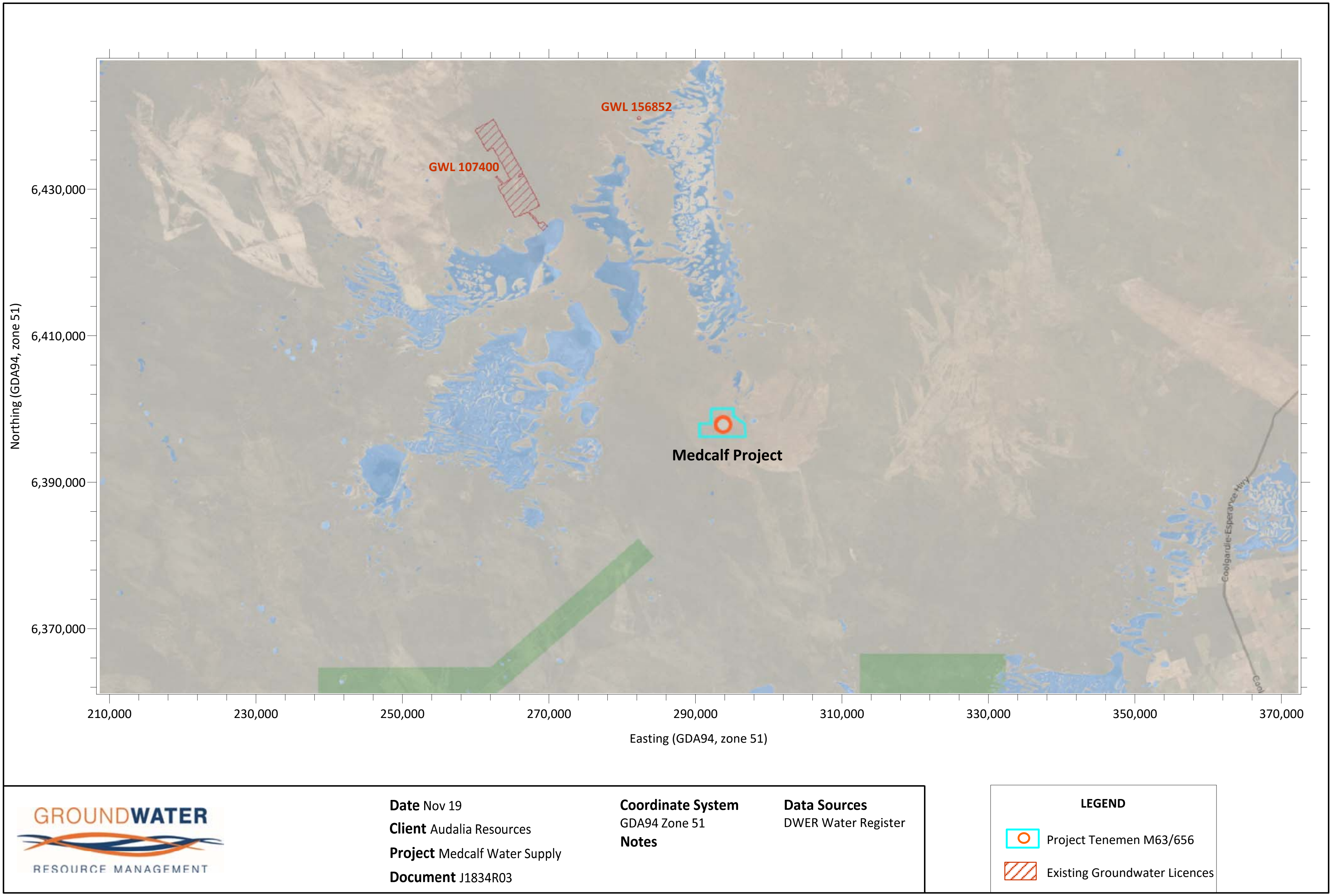
Data Sources
Lake Johnston topo
DWER WIR database
WASANT Palaeovalley Map

LEGEND
Project Tenements
WIR database bores
Palaeovalleys

GROUNDWATER RESOURCE MANAGEMENT

FILE://J1843 Audalia Medcalf/figures/surfer/J1843R03/J1843R03 Fig5 other groundwater users.srf

Figure 113: Registered bores near the Proposal



FILE://J1843 Audalia Medcalf/figures/surfer/J1843R03/J1843R03 Fig6 nearby groundwater licences.srf

Figure 114: Groundwater licences in the vicinity of the Proposal

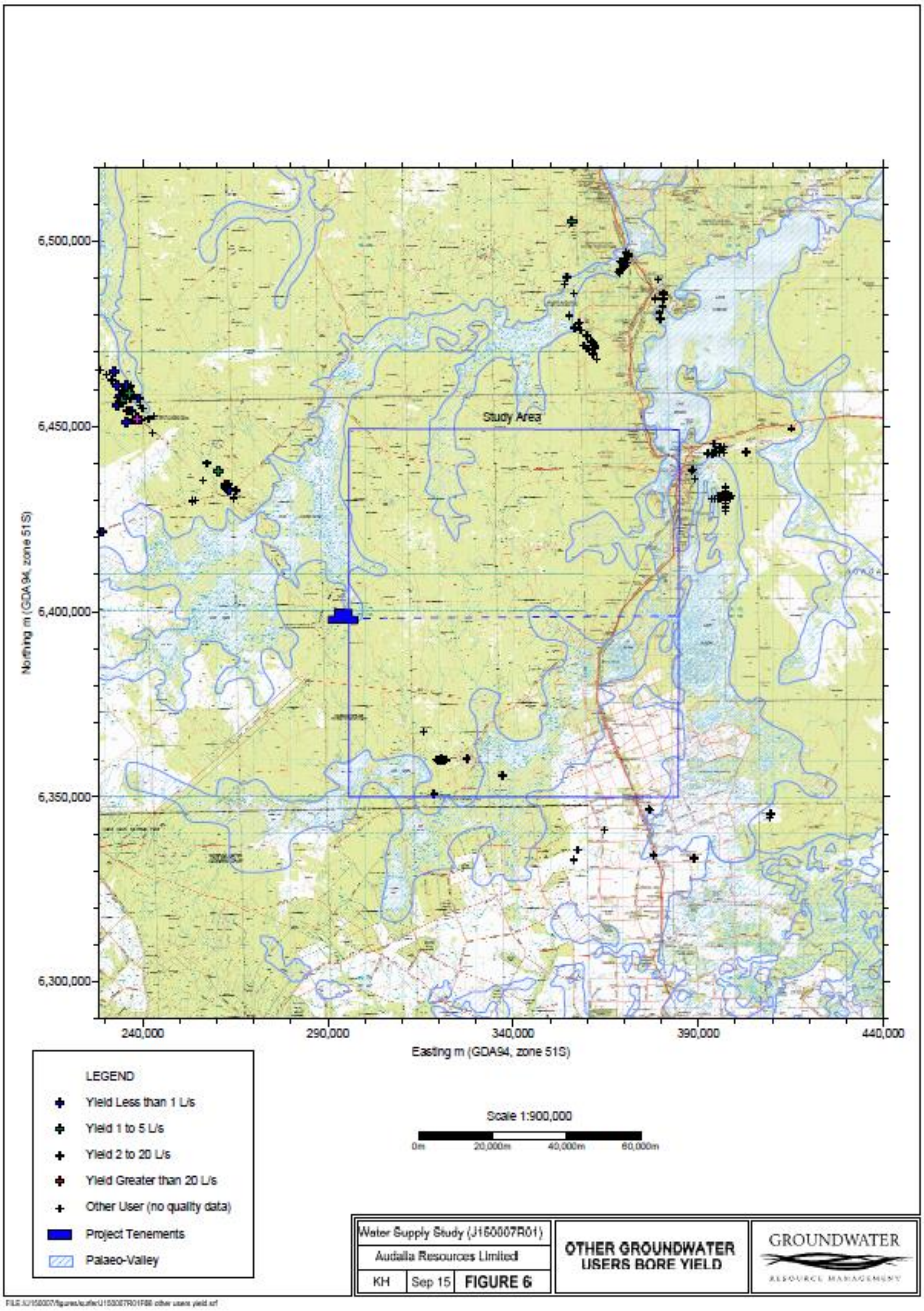


Figure 115: Regional groundwater bore yields

Groundwater System

A summary of the groundwater drilling results is provided in Table 69 and locations are shown in Figure 105. Only one of the locations is relevant to the haul road (MWH009) – this was drilled to a depth of 102 m to penetrate into the fractured rock aquifer.

Table 69: Exploration drilling results

Bore ID	Depth (mbgl)	Maximum Airlift Yield (L/s)	Main Aquifer Zone (mbgl)	Aquifer type
MWH001	120	1	46 - 54 60 - 66	Fractured bedrock
MWH002	30	<0.1	-	-
MWH003	39	4	16 - 26 34 - 36	Sand-weathered breccia
MWH004	45	5	16 - 27	Sand
MWH005	46	5	17 - 32	Sand
MWH006	30	0.5	29 - 30	Sand
MWH007	55	<0.1	-	-
MWH008	51	<0.1	-	-
MWH009	102	14	52 - 66	Fractured bedrock
MWH010	90	<0.1	-	-
MWH011	120	<0.1	-	-
MWH012	114	10	29 - 75	Fractured bedrock
MWH013	54	6	35 - 54	Fractured bedrock
MWH014	54	7	35 - 54	Fractured bedrock

The recent drilling indicates that the sand aquifer within the palaeotributary, which represents the regionally extensive Wollubar Sandstone, is approximately 10 m thick and at least 150 m wide in the vicinity of MWH003. Geophysical surveying has indicated the channel extends to the north northwest, which is consistent with the Kern (1995) palaeovalley map. A map of aquifer types shows the palaeotributaries, interfluves and greenstone aquifer areas identified from the desktop survey (Figure 116).

The depth to groundwater in the palaeotributary is less than 10 m below surface. The groundwater salinity, as measured in MWH003, is hypersaline (76,000 mg/L TDS) and the pH is low (3.7). The salinity is likely to increase down hydraulic gradient (i.e. to the north) as the groundwater becomes progressively more evolved.

Palaeochannel aquifers are recharged directly from rainfall in the upper channel reaches. Historically recharge to palaeodrainage systems across Australia has been episodic and most effective during the warm-wet interglacial periods (Magee, 2009). The sand unit is generally a continuous aquifer, on a regional scale, and has considerably greater storage potential and transmissivity than the adjacent fractured basement rocks.

The palaeotributary is incised into weathered ultramafics of the Archean Lake Johnston greenstone belt. Drilling has indicated additional permeability in this underlying unit (in

MWH003), which represents secondary permeability from chemical dissolution during weathering. The similar groundwater chemistry in both the palaeochannel sand aquifer and the underlying weathered basement (Table 70) indicate that they are likely to be in hydraulic connection.

At the western end of the Proposal, away from the palaeochannel, groundwater occurrences in the fresh bedrock are associated with discrete interconnected fractures. The fracturing is characterised by secondary permeability resulting from tectonic and decompression fracturing enhanced by chemical dissolution. Drilling has indicated modest yields from two drill-holes intercepting fractured bedrock aquifers (MWH009 and MWH012), which is consistent with other fractured bedrock aquifers in the Lake Johnston area. As a result of their discrete nature (i.e. having low storage characteristics), bedrock aquifers can dewater rapidly, and consequently are not always reliable as a long term water supply. Permeability in the bedrock away from these features is low, with low storage characteristics as evidenced by drill-holes MWH002, MWH010 and MWH011 which reported yields of less than 0.1 L/s.

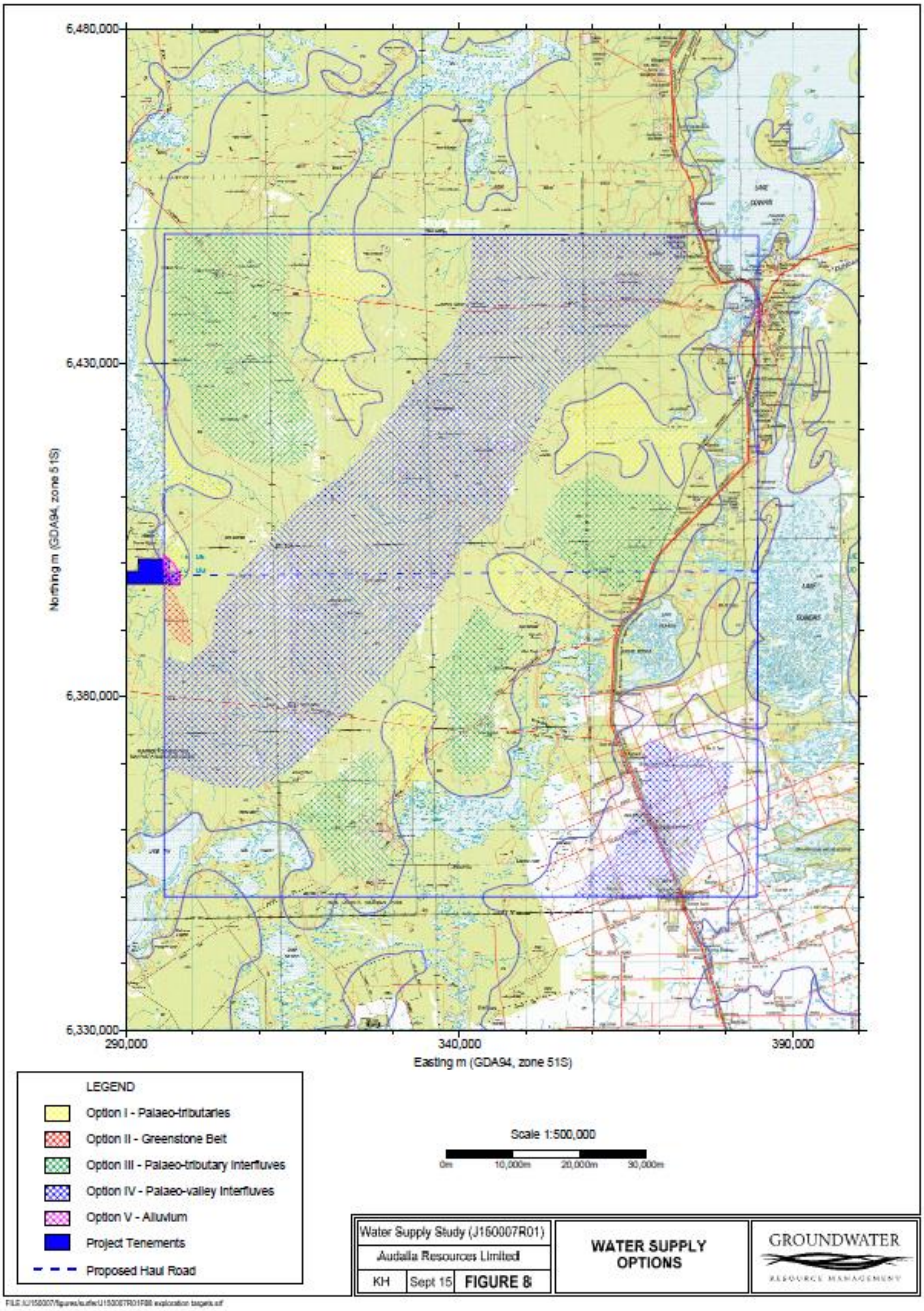


Figure 116: Aquifer types

Groundwater Quality

Regional groundwater quality (in terms of salinity) in the trunk palaeochannel aquifers are hypersaline, the palaeotributaries can be less saline, with the interfluves typically reporting the best quality groundwater (GRM, 2015). In geological settings with a deep weathering profile, fractured rock aquifers at the base of the saprock, within interfluves, are known to yield groundwater quality in the order of 15,000 - 30,000 mg/L TDS, which represents the best groundwater quality likely to be present in sustainably extractable quantities. Figure 117 shows available records of bore salinity, with few locations reporting salinities of less than 30,000 mg/L TDS.

GRM sampled the bores drilled for the water supply investigations undertaken during 2018 and 2019. The results of the water quality analysis from the Medcalf bores are provided in Table 70.

Table 70: Groundwater Quality

Analyte	Unit	MWH003	MWH003	MWH001	MWH009	MWH012	MWH013	MWH014	Driller's Bore
		PC06 Sand	PC06 Bedrock	D501	D801	DB03	DB04	DB01	KJC034
pH	-	3.7	3.8	7.2	7.0	7.6	7.9	7.6	7.7
EC	µS/cm	100,000	110,000	140,000	170,000	89,000	55,000	56,000	54,000
TDS	mg/L	76,000	85,000	120,000	160,000	62,000	41,000	42,000	36,000
Total Alkalinity as $CaCO_3$	mg/L	<5	<5	150	96	420	560	580	630
Carbonate Alkalinity as CO_3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as HCO_3	mg/L	<5	<5	180	120	520	680	710	760
Chloride	mg/L	39,000	45,000	63,000	90,000	36,000	20,000	21,000	19,000
Sulphate	mg/L	8,900	11,000	12,000	15,000	5,700	4,300	4,300	4,200
Nitrate	mg/L	<0.2	<0.2	0.4	0.3	0.3	0.85	0.82	<0.2
Calcium	mg/L	240	290	450	700	980	610	610	570
Magnesium	mg/L	3,400	4,000	4,700	6,600	2,900	1,700	1,700	1,700
Potassium	mg/L	260	230	340	540	200	120	120	110
Soluble Silicon as Silica	mg/L	87	64	9.8	19	31	37	40	40
Sodium	mg/L	18,000	22,000	34,000	44,000	17,000	10,000	9,900	9,400
Total Hardness	mg/L	14,000	17,000	20,000	29,000	14,000	8,600	8,300	8,300
Aluminium	µg/L	63,000	16,000	<250	<500	<250	<100	<100	<100
Iron	µg/L	54,000	86,000	<250	3,400	<250	<100	<100	<100
Manganese	µg/L	1,400	2,000	2,100	2,600	1,100	630	700	700

Groundwater in the fractured rock aquifer is saline to hypersaline, ranging from 36,000 mg/L TDS in the Drillers Bore to 160,000 mg/L TDS in MWH009 which is located closest to Lake Medcalf. The variability in salinity is consistent with regional conditions and is indicative of the complex nature of fractured rock environments.

The groundwater in the palaeochannel sand aquifer (MWH003) is acidic (pH 3.7) and hypersaline (76,000 mg/L TDS). The palaeochannel groundwater is significantly higher than the fractured rock aquifer in aluminium and iron which are attributed to acidity mobilising these elements from within the palaeochannel sediments.

Groundwater Dependant Ecosystems

A review of the BoM's GDE Atlas completed by GRM (2020a) for an area of 25 km surrounding the DEs indicates that the area is classified as having:

- No identified aquatic or subterranean GDE's within the DEs; and
- A moderate potential within and to the north of the DEs for terrestrial GDE's, and a low potential for terrestrial GDE's to the south of the Proposal.

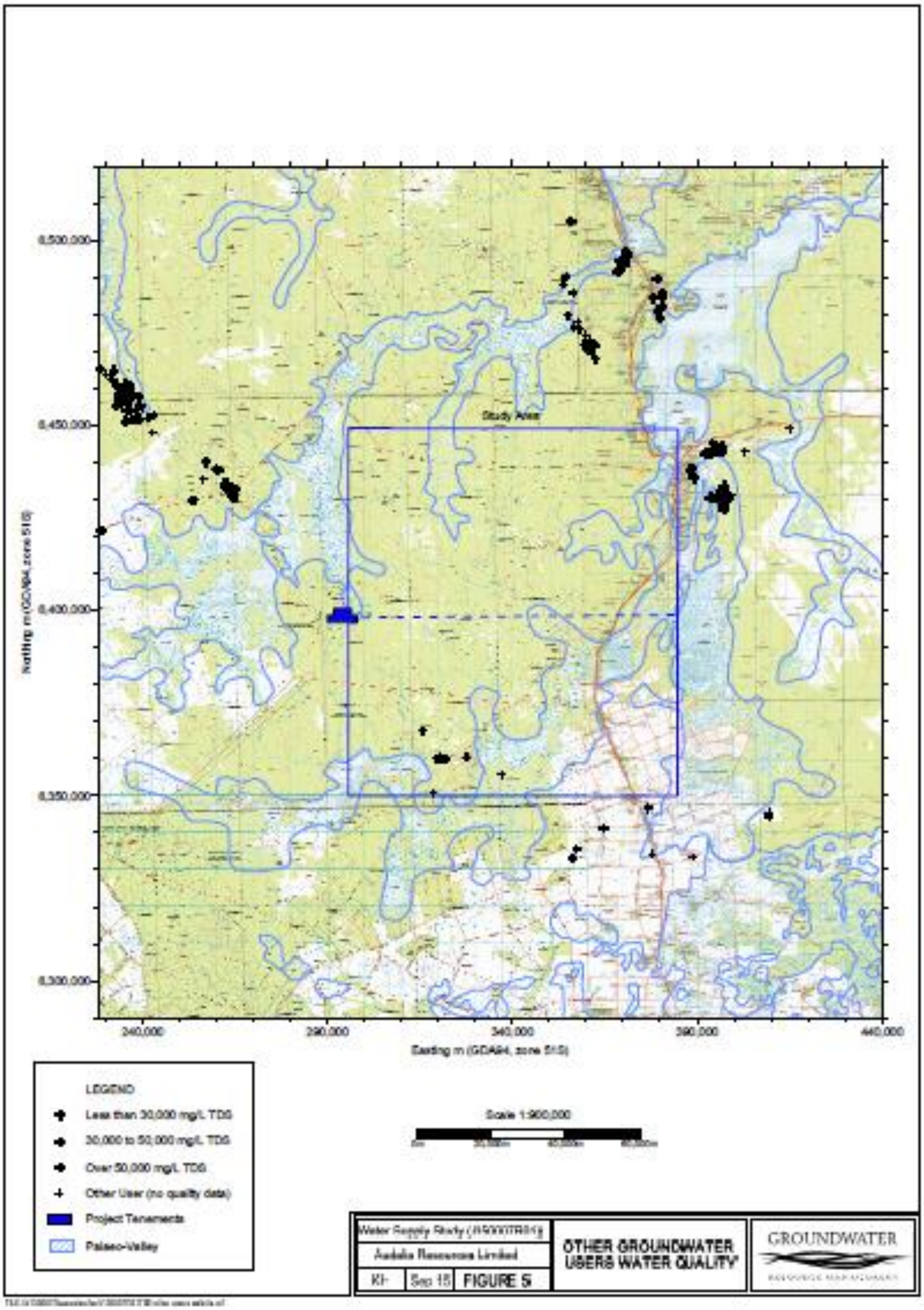


Figure 117: Regional groundwater salinity

Water Supply

The Proposal has a projected water demand of approximately 1.2 GL per annum, comprising:

- 0.8 GL per annum (25 L/s) of groundwater for the purposes of beneficiation, dust suppression within the mining area and camp supplies (which will need to be treated via reverse osmosis); and
- 0.4 GL per annum (12.7 L/s) of groundwater for dust suppression purposes along the 74 km haul road and transfer depot.

The exploration drilling results indicate that the mine water demand can be met by a combination of two fractured rock aquifer bores and two palaeochannel bores, assuming the acidity of the groundwater in the palaeochannel aquifer is acceptable.

The haul road groundwater supply will be sourced from a series of between three to five bores, roughly equidistant along the 74 km haul road. Individual bores will be capable of producing 2.5 - 4.2 L/s and be located within the Haul Road DE. Audalia is targeting a low salinity groundwater (<10,000 mg/L TDS), to minimise detrimental impact to equipment and vehicles. Previous studies undertaken by GRM (2015) identified three potential aquifers along the proposed haul road. A discussion of the potential water supply options is provided below:

1. **Palaeo-tributary aquifer within the Cowan Palaeodrainage**. Recent field investigations (GRM, 2020c) within the Lefroy palaeo-tributary adjacent to the mining area indicate a 10 m thick medium grained sand aquifer, overlain by a 16 m thick clay aquitard. Field investigations indicate individual bore yields in this aquifer of potentially around 4 - 5 L/s of hypersaline (76,000 mg/L TDS), although acidic (3.4 pH) groundwater. Given the regional similarities between the Lefroy and Cowan palaeodrainage systems, it is possible that similar yields and groundwater quality could be expected from the Cowan palaeo-tributary, although lower salinity is also possible based on other palaeo-tributaries in the region. Whilst the investigations conducted to date indicate this aquifer would be a suitable water supply source in terms of likely bore yields, the groundwater quality (salinity and pH) may limit their use;
2. **Fractured bedrock aquifers within the palaeo-tributary interfluves** (defined as un-dissected uplands between adjacent palaeo-tributaries). Regional information (GRM, 2015) indicates modest yielding low salinity aquifers can be found in palaeo-drainage interfluves. Recent investigations within the mining area (GRM, 2020c) indicated yields of up to 14 L/s in fractured bedrock bores, which is well above the required yield for the haul road water supply. However, the salinity in the mining area was highly variable, ranging from 54,000 - 170,000 mg/L TDS, which is likely attributed to the close proximity to the Lefroy palaeo-tributary. Lower salinity groundwater supplies are possible along the haul road corridor, particularly away from the palaeo-tributaries (i.e. closer to the catchment divides); and
3. **Surficial aquifers**. Regionally, small quantities of low salinity groundwater are known to occur in alluvial sequences, particularly along small drainage lines where the alluvium is sufficiently thick to extend below the water table. Surficial aquifers are readily recharged by rainfall, although supplies can diminish during prolonged dry periods. This aquifer type may provide a suitable shallow water source for the haul road.

In order to achieve three to five equidistant water supply bores along the haul road corridor the bores will likely comprise a combination of aquifer sources. A geophysical survey will be initiated along the corridor to further delineate the targets. Alternatively, Audalia may undertake a preliminary exploration drilling programme at the potential surficial aquifer targets shown on Figure 118, extending the drill holes into the underlying bedrock or palaeo-tributary sediments to assess two potential aquifer types per drill-hole.

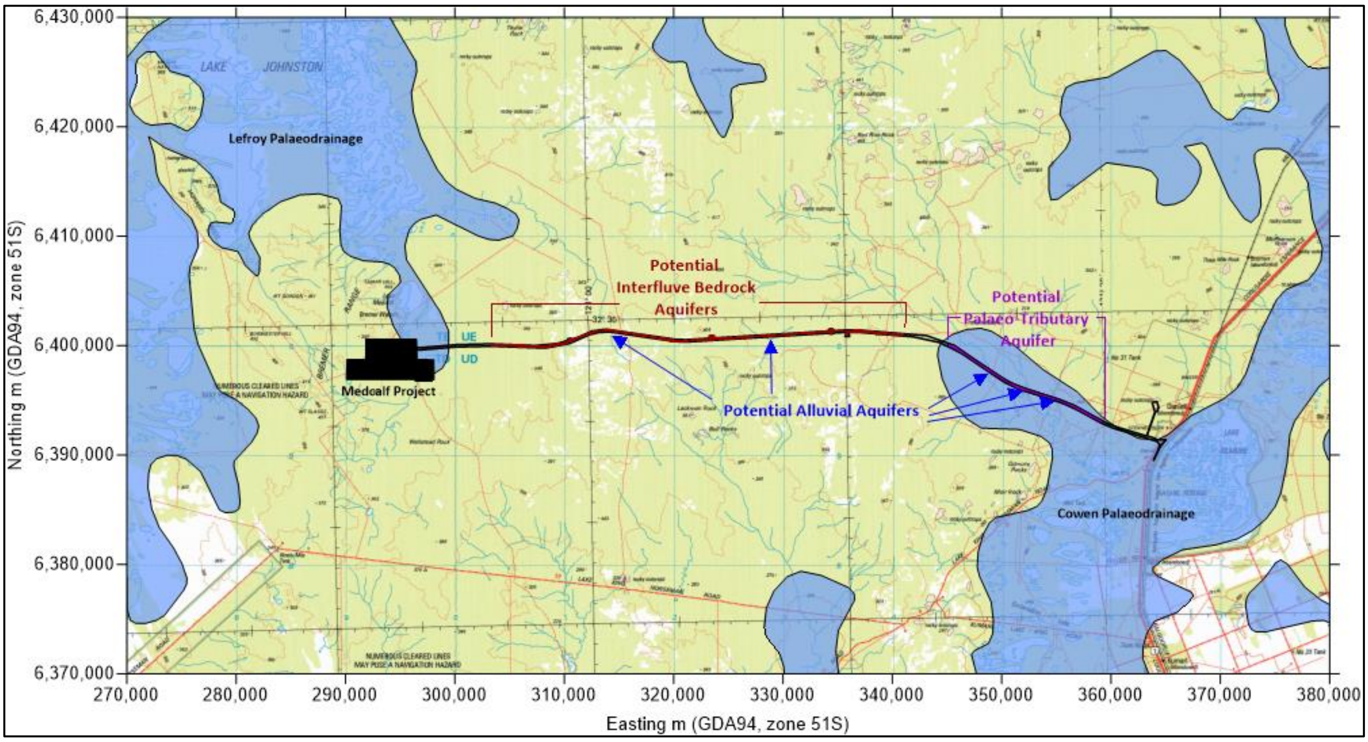


Figure 118: Haul road water supply options

9.3.6 Environmental Values

Based on the information provided in this section, the following environmental values were determined to require assessment for this factor:

- Surface water systems within the Haul Road DE;
- Surface water systems within the Mine DE;
- Surface water and catchments that intersect with the Optimal Habitat of *M. aquilonaris*;
- Groundwater underlying the Mine DE; and
- Groundwater underlying the Haul Road DE.

9.4 Potential Impacts

Table 71 defines the potential impacts (direct, indirect and cumulative) on the environmental value for this factor in a local and regional context.

Table 71: Potential impacts on inland water.

Environmental value	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Surface water systems within the Haul Road DE	Disturbance within the boundary of 20 catchments.	Changes to surface water flow regimes. Erosion caused by re-directed concentrated water flows. Sedimentation as a result of scour caused by road drainage. Contamination from pollutants spilt or accumulated on the road surface, or saline water use.	No other proposals in the immediate area that currently impact these catchments.	Disturbance within the boundary of 20 catchments and potential indirect erosion and water quality impacts.
Surface water systems within the Mine DE	Disturbance within the boundary of two catchments. Diversion of one drainage line	Changes to surface water flow regimes. Erosion caused by vegetation clearing and re-directed concentrated water flows. Sedimentation as a result of sediment loss from cleared areas. Contamination of surface water flows from spills of hydrocarbons, chemicals, sewage or saline water.	No other proposals in the immediate area that currently impact these creeklines.	Disturbance within the boundary of two catchments and potential indirect erosion and water quality impacts.
Surface water and catchments that intersect with the Optimal Habitat of *M. aquilonaris.*	0.56 ha of disturbance within the catchment above Optimal Habitat. No disturbance within the catchment above sub-populations.	Changes in surface water flow volumes and water balance within unoccupied area of Optimal Habitat. Mobilisation and deposition of sediment during construction. Contamination of surface water flows from hydrocarbon or chemical spills, or spills of saline water	Some existing tracks lie within the upslope catchments.	0.56 ha of disturbance within the catchment above Optimal Habitat. No disturbance within the catchment above sub-populations. Changes in surface water flow volumes and water balance within unoccupied area of Optimal Habitat. Other potential indirect impacts.
Groundwater underlying the Mine DE	Abstraction of 0.8 GL/yr from the fractured rock and/or palaeochannel aquifers	Drawdown of groundwater around abstraction bores. Localised mounding of groundwater from TSF / evaporation ponds seepage. Leaching of contaminants from the TSF / evaporation ponds into the underlying groundwater. Hydrocarbon and chemical spills causing contamination of groundwater. Leaks or spills of saline water or desalination brine into groundwater.	No other proposals are currently accessing or otherwise impacting the aquifers that occur within the Mine DE.	Abstraction of 0.8 GL/yr from the fractured rock and/or palaeochannel aquifers aquifer and associated drawdown. Localised mounding of groundwater from TSF / evaporation ponds. Potential contamination.

Environmental value	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Groundwater underlying the Haul Road DE	Abstraction of 0.4 GL/yr from palaeo-tributary, fractured bedrock and/or surficial aquifers	Drawdown of groundwater around abstraction bores. Hydrocarbon and chemical spills causing contamination.	No other proposals are currently accessing or otherwise impacting these aquifers in proximity to the haul road.	Abstraction of 0.4 GL/yr from palaeo-tributary, fractured bedrock and/or surficial aquifers Potential indirect drawdown and contamination impacts

9.5 Assessment of Impacts

9.5.1 Surface Water Systems within the Haul Road Development Envelope

Direct Disturbance

The construction of the haul road will require disturbance within the boundaries of surface water systems, with 20 catchments intersected by the haul road, and up to 28 surface water crossings. The haul road will be a graded, two lane, dirt or gravel surfaced road constructed generally on the ground surface (i.e. not built up). Low earth banks may form on the sides of the road as a result of grading or may be constructed as safety berms. The road in places may have table drains on one or both sides of the roadway with turnout drains discharging stormwater to the environment.

These catchments intersected by the haul road are divided within the three following hydrologic regimes:

1. Overland flow areas;
2. Diffuse drainage lines; and
3. Lakes and associated drainage lines.

Overland flow can occur all along the alignment but the amount and frequency of flow is heavily influenced by soil types, surface cover and land surface grade. Monitoring and control measures will be in place to mitigate overflow impacts along the haul road (refer to Section 9.6).

A number of diffuse drainage lines cross the alignment. These are poorly defined water courses that either dissipate in flat areas or flow into nearby lake systems. Drainage lines may infrequently carry stormwater as shallow overland flow but these are not considered to cause significant impact.

In some places playas or lakes lie within about 1 km to the alignment. These should be unaffected by the proposed haul road as most appear to be hydraulically disconnected from flows crossing the roadway.

The only lake that is connected to the road alignment via a well-defined stream channel is Lake Medcalf. Lake Medcalf is within about 4 km of the alignment via a tributary channel. It is possible that the channel would be in direct contact during runoff events when the Lake Medcalf holds water.

The disturbance required for the haul road is a relatively narrow portion of any surface water system or catchment, with the haul road making up only 0.3% of the catchments. This disturbance is considered unlikely to significantly impact the quality of these surface water systems.

Changes to surface hydrology flow regimes

The development of the haul road has the potential to influence the flow regimes of the surface water systems that it intersects. Environmental impacts associated with linear infrastructure features (tracks, roads and rail lines) has been investigated in the Great Western Woodlands by Raiter (2016). The study reviewed 285 drainage crossings and found that 62% showed signs of flow impedance, 73% showed diversion of flows and 76% showed concentration of flows. 31% of crossings showed signs of channel initiation. Flow diversion was found to be more common where culverts were used.

The preferred route selected for the haul road is well aligned with topographic divides, avoiding the need for crossings of any significant surface water drainage features except a tributary of Lake Medcalf.

NSW Office of Environment and Heritage (2012) have prepared guidance on erosion and sediment control on unsealed roads. The principles of this guidance have been adopted as the design basis for the road drainage to reduce the risk of impeding, diverting and concentrating surface water flows. Taking this into consideration, GRM (2020a) proposed three types of structures for drainage lines crossing the haul road; causeway, floodway or no formal structure (Table 72).

The only crossing that requires a causeway is Crossing 1 (Figure 107), which is a broad but well defined streamline and tributary of Lake Medcalf. Crossing 1 is the only crossing point for catchment 3, which at 148 km^2 is one of the larger catchments traversed by the haul road. It is likely that water flows in the channel toward Lake Medcalf during and after rainfall events. As the lake fills, water could pond at the crossing location for some time, gradually dissipating to infiltration and evaporation.

A causeway is considered an appropriate structure for this location as it caters for both flowing and ponded water. The structure would take the form of an elevated roadway with low-flow culverts. The roadway would be designed as a floodway for larger events. Flow concentration will be minimised to reduce impact on the downstream hydrologic regime and to minimise scour.

Floodways are proposed for most other crossings where there is a defined drainage channel or valley and a moderate or large contributing catchment (Table 72). Floodways would take the form of a protected road surface and free drainage to the floodway upstream and downstream. Roadside berms will be discontinued through the floodway. Floodways should be constructed so as to not unduly concentrate flows.

No formal structure is suggested for areas where the contributing catchment is small and there is no defined drainage line. These areas are, however, topographic low points and may convey or pond water after heavy rainfall. The design of the roadway and maintenance regime in these areas will account for the possibility of flow and ponding by discontinuing roadside berms through the low point where overland flow may concentrate.

Table 72: Haul Road Crossings

Crossing	Crossing Type	Description
1	Causeway	Lake Medcalf tributary. Defined channel with likely flowing and ponded water.
2	Floodway	Diffuse drainage line but a large catchment. Allow for shallow overland flow and/or ponding.
3 - 7	No formal structure	Diffuse drainage line and a small catchment. No structure may be viable, but may need road maintenance after rainfall events.
8	Floodway	Diffuse drainage line and a small catchment. Allow for shallow overland flow and/or ponding.
9 - 12	No formal structure	Diffuse drainage line and a small catchment. No structure may be viable, but may need road maintenance after rainfall events.
13	Floodway	Diffuse drainage line. Allow for shallow overland flow and/or ponding.
14	Floodway	Diffuse drainage line, continuation of drainage line from Crossing 13. Allow for shallow overland flow and/or ponding.
15 - 16	No formal structure	Diffuse drainage line and a small catchment. No structure may be viable, but may need road maintenance after rainfall events.
17	Floodway	Ill-defined drainage line but a moderate sized catchment. Allow for shallow overland flow and/or ponding.
18 - 20	No formal structure	Diffuse drainage line and a small catchment. No structure may be viable, but may need road maintenance after rainfall events.
21	Floodway	Diffuse drainage line. Allow for shallow overland flow and/or ponding.
22	Floodway	Diffuse drainage line but a large catchment. Allow for shallow overland flow and/or ponding. Possibly larger flows in bigger events.
23 - 24	Floodway	Diffuse drainage line and a moderate-sized catchment. Allow for shallow overland flow and/or ponding.
25	No formal structure	Diffuse drainage line and a small catchment. No structure may be viable, but may need road maintenance after rainfall events.
26	Floodway	Diffuse drainage line, possibly the upper reaches of a playa. Allow for shallow overland flow and/or ponding.
27 - 28	No formal structure	Diffuse drainage line and a small catchment. No structure may be viable, but may need road maintenance after rainfall events.

Road formation will include camber and roadside drainage (table and mitre drains) along its length. Allowance has been made for disturbance associated with these structures. Inappropriate sizing and spacing of these features can lead to impedance, diversion and concentration of flows to the extent that gullying and sedimentation may occur. Regular inspections, maintenance and retro-fitting drainage improvements is required to manage these occurrences.

The location and route of the haul road, incorporation of natural drainage considerations into road design, the scale and frequency of drainage features and runoff events means that the extent of disruption to surface flows is not expected to be significant. Monitoring, maintenance and retro-fitting improved drainage where required will further reduce the frequency and consequence of any impacts to surface drainage.

Erosion and sedimentation

Linear infrastructure features such as the haul road can create erosion of soils, particularly where inadequate allowance is made for drainage. Raiter (2016) reviewed the occurrence of soil erosion associated with linear infrastructure in the Great Western Woodlands and identified a high level of association between linear infrastructure and erosion frequency and severity. This is likely to be a result of the large number of linear infrastructure features in the Great Western Woodlands that have been constructed with very basic approaches and machinery.

The haul road may also cause mobilisation and deposition of sediment as a result of scour caused by the new road drainage features. Appropriate shaping of the road profile, use of table drains to manage runoff, maintenance and retro-fitting drainage controls will be used to minimise scour of the roadway and adjacent natural drainage. Post-event visual monitoring of sedimentation along the length of the haul road will be used to manage the extent of erosion and deposition caused by the road drainage.

The risk of significant erosion and sedimentation caused by the haul road can be significantly reduced by adopting sound surface water design principles. GRM (2020c) have assessed surface water drainage and recommended 28 crossings, with accommodation of shallow overland flow areas to reduce the risk of concentrating flows and causing erosion (as described in the section above).

NSW Office of Environment and Heritage (2012) have prepared guidance on erosion and sediment control on unsealed roads. The principles of this guidance have been adopted as the design basis for the road drainage to reduce the risk of causing erosion.

The location and route of the haul road, incorporation of natural drainage considerations into road design, the scale and frequency of drainage features and runoff events and commitment to post-event monitoring means that the extent of erosion and deposition caused by the road drainage is not expected to be significant.

Contamination or Salinification

Discharge of pollutants from the road surface could occur as a result of entrainment of applied or spilt material being mobilised by runoff during a runoff event. The pollutants with the greatest potential to accumulate on the road surface are hydrocarbons.

Impacts to surface water systems from hydrocarbon spills would be most significant if spilt on the road surface from a catastrophic incident such as a traffic accident – in which case the location and impact would be immediately obvious. Significant spillage (i.e. >100 L of hydrocarbons caused by roll-over of a fuel delivery truck), would require immediate control measures to contain the spread of spilt hydrocarbons, care not to ignite the material, and a substantial clean up. Reports would be made to relevant authorities and clean up commenced at an appropriate time agreed with authorities. Smaller spillages associated with ruptured hydraulics will be more frequent and result in smaller quantities.

Emergency response training and procedures will include significant incidents such as traffic incidents and include control measures for any significant hydrocarbons spillage. Incident reporting procedures will include thresholds for hydrocarbon spillage designed to ensure that contamination from spilt hydrocarbons on the road surface does not escape to contaminate the adjacent environment.

Specific water supply sources for dust control on the haul road have not yet been identified. Given the lack of fresh groundwater in the region, it is likely that one or more of the sources will be saline. If saline water is used on the road surface, accumulated salts could be washed off in subsequent rainfall events. Large runoff events would be expected to provide significant dilution of salts accumulated on the road surface, however smaller events may result in small flows of saline water escaping from the roadside drainage. Roadside design incorporates the collection and storage of these salts in table drains, and mitigation measures are proposed in Section 9.6 to minimise these impacts further.

9.5.2 SURFACE WATER SYSTEMS WITHIN THE MINE DEVELOPMENT ENVELOPE

Direct Disturbance

Proposed infrastructure that will be located inside the Mine DE includes pits, processing areas, tailings storage facility, camp and roads.

Three main catchments and a number of sub-catchments and drainage lines were identified within the Mine DE (Figure 109). Drainage through the area of the mine site is defined by a line of low hills trending in an east-west direction through the Fuji and Vesuvius pits. Drainage from the hills through the site area is generally either toward the north or south.

The Proposal will result in direct impacts to the upper portions of the three main catchments (Figure 107). Catchment 1 is 5.9 km^2 and only a small portion of the Vesuvius and Fuji mine pits lie within this catchment (at the catchment divide). There are no defined drainage lines in these areas and therefore is considered unlikely that the Proposal will significantly impact the surface water systems within this catchment.

Catchment 2 is 2.0 km^2 and contains the remainder of the Fuji pit, as well as a portion of the Pinatubo pit. The ROM pad and access roads are also located within this catchment. Given the small size of this catchment it is estimated that 10 – 15% of the catchment would be impacted by the Proposal. The Pinatubo pit will also intersect a small ephemeral drainage line (Figure 109). This catchment drains to Lake Medcalf, as does a large number of other catchments, therefore the disturbance within this catchment is unlikely to be significant in a regional context.

Catchment 3 is 162.6 km^2 and contains the majority of the mining infrastructure, as well as the Egmont pit and a portion of the Pinatubo pit. Given the large size of this catchment it is estimated that less than 2% of the catchment would be impacted by the Proposal therefore the disturbance within this catchment is unlikely to be significant.

Changes to surface hydrology flow regimes

As discussed in the section above, the Proposal will intersect only small portions of the catchments, therefore significant changes in surface water flow volumes are unlikely.

Several drainage lines will be intersected by the Proposal (Figure 109), with diversions proposed at the TSF, evaporation ponds and Pinatubo pit (Figure 3). These diversions are high in the catchment and will be engineered structures designed to allow the majority of the flows to be maintained. As such the impact to downstream surface water regimes are likely to be minor.

Erosion and Sedimentation

The mine infrastructure are located high in each catchment and as such flow volumes are unlikely to be high through these areas. The drainage diversions around the TSF and evaporation ponds include a sediment pond prior to release to the natural downstream drainage system. These ponds will be sized to allow sufficient holding time to enable the majority of sediment to drop out of the water column prior to release.

Based on the above, erosion and sediment losses are expected to be able to be adequately minimised using the mitigation measures proposed in Section 9.6 such that they do not have a significant impact on surface water systems.

Contamination of surface water

Considering the hydrocarbons use described in Section 8.5.6, and the small scale of operations planned for Medcalf, large-scale hydrocarbon spills are considered unlikely. Small hydrocarbon spills associated with hydraulics failures on machinery and refuelling spills may occur on occasion in operational areas. Spills generally result in a defined area of hydrocarbon contaminated soil that can be remediated via passive means such as bioremediation. Proposed control measures are identified in section 0 and are designed to further reduce the risk of surface water contamination from hydrocarbon spillage.

An estimated 15 - 45 kL of sewage from the accommodation camp will be treated at a wastewater treatment plant each day. The treated wastewater will be disposed of via irrigation to a dedicated area adjacent to the camp, located away from surface water drainage lines. The wastewater will be treated to a minimum low exposure risk level quality and licenced under Part V of the EP Act and the *Health Act 1911*.

Saline water pipelines will run from the borefield to the RO Plant, then from the RO Plant to the evaporation ponds. A rupture of these pipelines has the potential to release saline water into the surrounding fresh water catchment if it were to occur. Leak detection is proposed for these pipelines, which will trigger an automatic shut-down of the borefield or RO Plant feed. This will restrict the volume of saline water that would be released into the surrounding environment. Audalia will also investigate the option of containing a spill if it was to occur, by placing the pipes in a system of bunds and sumps designed to contain spillage. This option however may not be pursued along the whole length of the pipelines as the area likely to be affected by a spill may be less than the clearing of vegetation required to develop this containment infrastructure. The details of these systems are generally planned and managed via a Works Approvals under Part V of the EP Act (for the RO Plant, evaporation ponds and Process Plant) and a Mining Proposal under the Mining Act. Additional mitigation measures are proposed in Section 9.6 to minimise the change and potential impact of a saline water pipeline spill.

9.5.3 SURFACE WATER AND CATCHMENTS THAT INTERSECT *M. AQUILONARIS* OPTIMAL HABITAT

Section 9.3.3 provides information about the surface water catchments above the *M. aquilonaris* sub-populations and optimal habitat areas.

The Proposal has been revised to ensure that the Mine DE does not encroach into the upslope catchment of any current *M. aquilonaris* sub-populations (Figure 63). The Proposal will however result in the disturbance of 0.56 ha of the catchment above the optimal habitat for sub-population 1c (Figure 64). This equates to a 33% reduction in the 1.69 ha upslope catchment.

The reduction in the catchment is considered unlikely to reduce the viability of the optimal habitat, as the sub-populations for this species lie across catchment divides (Figure 63), indicating that the species is unlikely to be reliant on upslope surface water runoff for survival.

Mitigation measures are proposed to ensure that upslope surface water runoff is able to pass through the abandonment bund (Section 5.6).

The significance of the impacts described above is best discussed in the context of impacts to *M. aquilonaris* (refer to Section 5.5.2).

9.5.4 GROUNDWATER UNDERLYING THE MINE DEVELOPMENT ENVELOPE

Groundwater Abstraction and Drawdown

Mining does not extend into the water table, so no mine dewatering is required. However up to 0.8 GL/yr of water will be required for processing, dust suppression and personnel purposes. GRM (2020b) has assessed the potential for the fractured rock and/or palaeochannel aquifers close to the mine to provide sustainable supplies of this water.

The results of the field investigations indicate that the Proposal water demand could potentially be met by a combination of two fractured rock bores and two palaeochannel bores, assuming the acidity of the groundwater in the palaeochannel aquifer is acceptable. Whilst the yields were higher in the two fractured rock bores, the palaeochannel bores are likely to be more reliable in the longer term, as fractured rock aquifers commonly have low storage and yields can diminish with time.

<u>Conceptual Modelling</u>

A conceptual model and groundwater flow model was developed to assess likely drawdown impacts associated with groundwater abstraction from the fractured rock and palaeochannel aquifers. The modelling will be refined once the production bores are installed and tested (GRM, 2020b).

The conceptual model for the area recognises six distinct hydrogeological units (shown schematically in Figure 119):

- Hydrogeological Unit (HU) 1 - surficial deposits which may extend below the water table comprised of a combination of mixed alluvium, which provide recharge to the broader groundwater environment;
- HU2 - low permeability clayey sequence forming the broader shallow groundwater environment across the palaeovalley (the Perkollili Shale). Hydraulic test data indicates a low permeability with hydraulic conductivity of 0.001 m/d and generally forms an aquitard. The unit is recharged via leakage from the HU1, and potentially also from fractured bedrock (HU5) in localised areas where the two units are in contact;
- HU3 - sand aquifer at the base of the palaeochannel, the Wollubar Sandstone. Comprised of medium grained sand with minor basal gravel noted to be 10 m thick in the vicinity of MWH003 and 150 m wide. Modest permeability and modest aquifer storage. Recharge to the aquifer is primarily via adjacent fractured rock (HU5) in contact with the sand, with limited recharge via leakage from the overlying HU2;

- HU4 - the weathered bedrock beneath the sand aquifer. The HU4 is in hydraulic connection to the HU3, and recharged via adjacent fractured bedrock (HU5);
- HU5 - the fractured bedrock aquifers. Modest permeability and low aquifer storage, recharged predominantly by other similar structures and ultimately by the HU1 or direct rainfall recharge; and
- HU6 - the un-fractured bedrock, away from the HU5 fracture zones. Considered an aquitard, with low permeability and low aquifer storage.

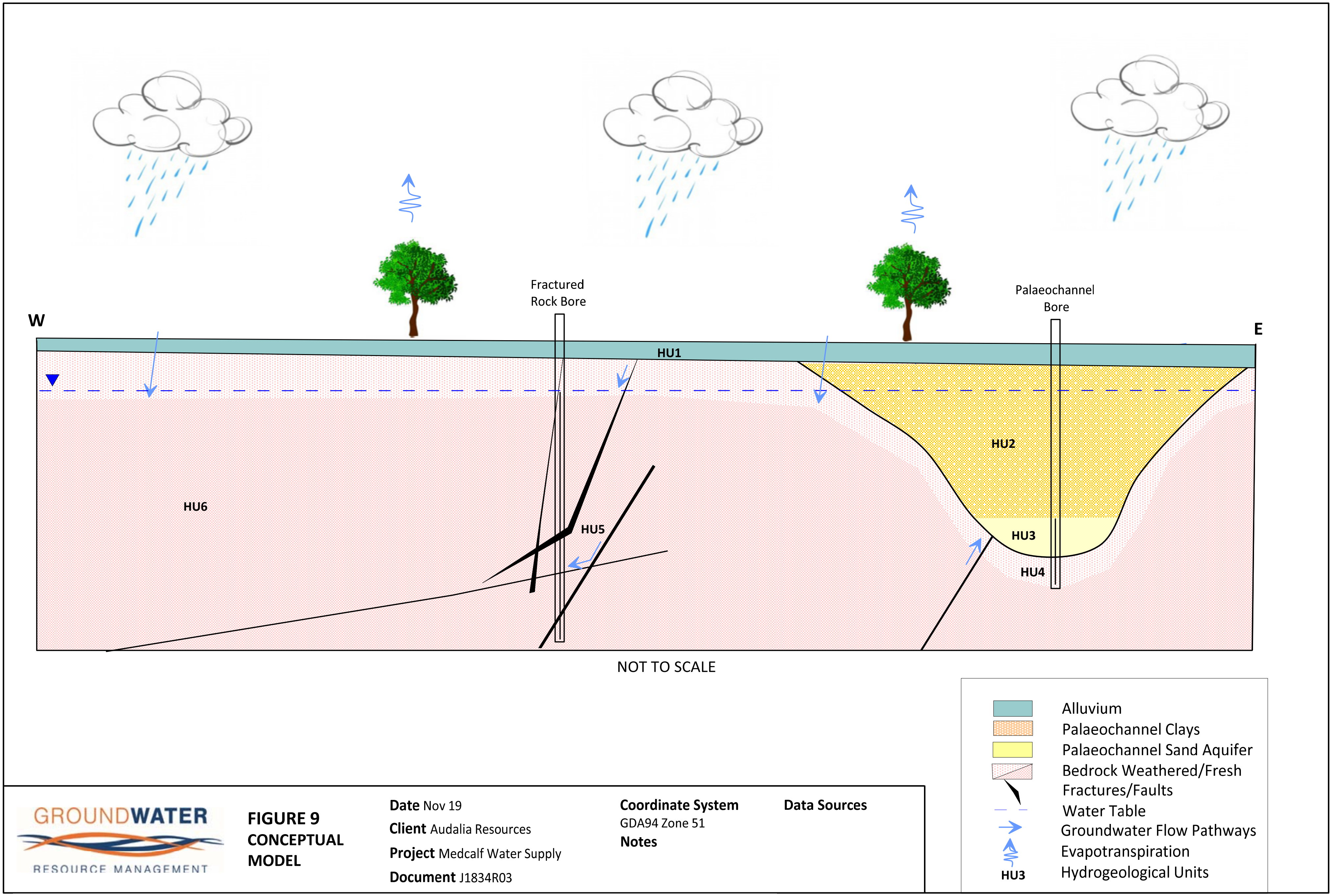


Figure 119: Conceptual model

Groundwater Flow Modelling

A numerical groundwater flow model was developed by GRM (2020b) for the palaeochannel and surrounding bedrock environment, based on the conceptual model described above.

The model was developed to provide a preliminary assessment of drawdown impacts associated with groundwater abstraction from four proposed production bores (Figure 120), namely:

- MWB01, installed into the Wollubar Sandstone and underlying weathered basement, adjacent to exploration drill-hole MWH003;
- MWB02, installed into the Wollubar Sandstone and underlying weathered basement, located 1 km north of MWH003;
- MWB03, installed into the fractured bedrock aquifer, adjacent to exploration drill-hole MWH012; and
- MWB04, installed into the fractured bedrock aquifer, adjacent to exploration drill-hole MWH009.

The predicted drawdowns at the end of the 13 year mine life are shown in Figure 120. The modelling results indicate:

- Abstraction from the bores will result in groundwater drawdown extending linearly along the higher permeability features (i.e. along the palaeochannel sand aquifer or along the fracture orientation), with limited drawdown extending laterally into the adjacent low permeability intact bedrock;
- The overlying Perkollili Shale will likely act as a semi confining layer, limiting leakage to the underlying Wollubar Sandstone aquifer and resulting in limited drawdown in the shallow groundwater system; and
- At the end of the 13 year simulation, drawdown along the palaeochannel is less than 2 m at the southern extent of the palaeochannel (south east from MWB01) and less than 1 m across the remainder of the palaeochannel. The drawdown is limited in the palaeochannel due to the overlying semi-confining clay layer. Drawdown in more pronounced in the fractured bedrock with the 1 m drawdown contour extending approximately 2 km along strike from the fractured rock bores.

The risk of environmental impact to other groundwater uses or users, the groundwater environment and the GDE's as a result of groundwater abstraction from the proposed water supply bores is considered low, given that:

- The drawdown around the bores is likely to be localised;
- The nearest licenced groundwater user is 35 km from the Proposal; and
- The groundwater is hypersaline, and of limited use, other than for mining and industrial purposes.

The Proposal lies within an unproclaimed groundwater area under the RIWI Act and is not subject to licensing unless abstraction is from a confined or semi-confined aquifer. Test-pumping is required to confirm the status of the paleochannel aquifer and determine whether a 5C Licence is required. Nevertheless, with industry standard monitoring, groundwater extraction for mine water supply is not expected to result in significant environmental impacts.

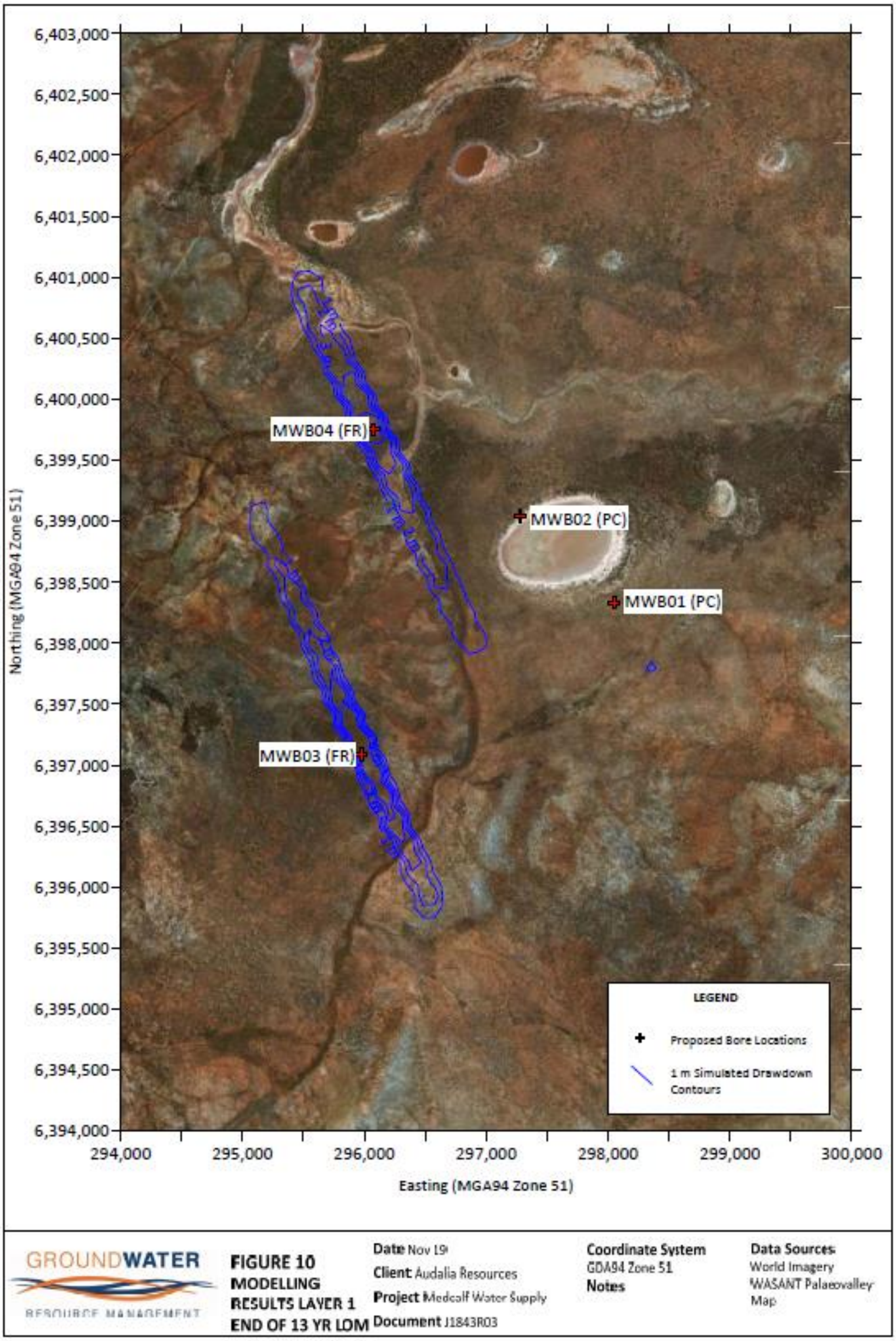


Figure 120: Modelling results layer 1 end of 13 year LOM

Groundwater Mounding

Groundwater mounding may occur beneath the TSF / evaporation ponds footprint due to seepage from the base of these facilities.

The TSF and evaporation ponds are located in an area with no beneficial users or uses of the aquifer (GRM, 2020b) and the expected significant depth to groundwater (based on surrounding site groundwater bores and topography) is 30 - 40 mbgl. It is therefore unlikely that localised seepage will result in a significant rise in groundwater levels such that the root zone of any nearby vegetation would be affected.

Additional groundwater mounding from seepage may add pressure head to the naturally hypersaline aquifer however it is unlikely that this would express itself close to the soil surface further down the catchment. It is approximately 3 km downslope of the TSF / evaporation ponds before the topographic low of the valley is encountered, providing a significant buffering distance. With no deep seepage controls (liners or underdrainage), seepage has been assumed as being between 5 - 15% of input water to the TSF (Golder, 2020).

The above assessment is based on preliminary TSF and evaporation pond designs, and detailed designs will be required to be prepared and assessed under the Mining Act and Part V of the EP Act should the Proposal proceed.

Options to mitigate seepage and mounding from the TSF include:

- Under-drainage system to reduce seepage;
- Deep monitoring and pump-back bores located downslope;
- Compacted in-situ materials in the base of the TSF; and
- Use of liners.

The potential for seepage and mounding is usually assessed based on the detailed design of the TSF and evaporation ponds and is required for both the Works Approval and Mining Proposal. A system of monitoring bores will be proposed with trigger values based on groundwater level designed to identify if groundwater was approaching the root zone within any downslope vegetation. Given the low throughput of the operation (0.5 Mtpa of tailings annually) and significant separation between base of the TSF / evaporation ponds and groundwater, it is unlikely that pump-back bores to maintain groundwater separation from root zone would be required. Further detail regarding mitigation measures is provided in Section 9.6.2.

TSF and evaporation pond monitoring required under the Mining Act and Part V of the EP Act will also include inspections of all sides of the TSF and evaporation ponds, including the slope and toe for evidence of seepage. The toe drain allowed for on the crest of the TSF starter embankment will also be inspected for evidence of seepage. Annual TSF audits will also include a review of all piezometer data and the annual geotechnical inspection conducted by a certified engineer.

The relatively small scale of operations, together with the lack of other uses, or any nearby users of the hypersaline groundwater make the risk of significant impacts to the groundwater system from the TSF or evaporation ponds low. With the implementation of monitoring and mitigation measures regulated under the Mining Act and Part V of the EP Act, groundwater mounding from the TSF and evaporation ponds are not expected to result in significant impacts to this factor.

Seepage Contamination from TSF / Evaporation Ponds

As the TSF and evaporation ponds will not be lined, it is likely that leachate / seepage from these facilities will reach the underlying groundwater. Groundwater under the proposed TSF and evaporation ponds is hypersaline (36,000 - 160,000 mg/L TDS and is estimated to be 30 - 40 m below the base of these facilities (Golder, 2020).

As detailed in Section 8.5.2, seepage from the TSF will be fresh water with insufficient concentrations of any contaminants to be toxic to plants or represent a risk to surface or groundwater.

Seepage from the evaporation ponds will be hypersaline – further concentrated in salts, but the same suite of salts as from the natural groundwater. Shallow seepage (seepage water travelling laterally underground within the likely plant root zone could potentially impact on plants via root uptake, or surface expression if pressure heads were large enough. The same sort of controls as are generally applied to TSFs are planned for the evaporation ponds:

- Embankment is keyed into stable ground;
- Layer of low permeability material used in construction to prevent seepage through the embankment;
- Underdrainage to collect seepage and direct it safely through the embankment to a catch dam at the toe of the embankment; and
- Cut-off trench on the downslope side of the embankment to capture shallow seepage and direct it to the catch dam.

A liner is not proposed to prevent seepage from the evaporation ponds for the following reasons:

- The salts being retained are the same salts as naturally occur in concentrations that are toxic to plants in the natural groundwater;
- The liner will result in more salts accumulating, requiring disposal at mine closure; and
- Liners themselves require removal and disposal at the end of mine life.

Noting that the groundwater is naturally hypersaline and there are no nearby uses or users for groundwater, and, given the depth to groundwater; seepage of fresh or hypersaline water into the groundwater system is not expected to represent a significant environmental risk. With the adoption of appropriate controls, the risk is expected to be further reduced.

The TSF and evaporation ponds will be regulated under Part V of the EP Act (Category 5 Processing or beneficiation of metallic or non-metallic ore) which will require protective measures, monitoring and reporting of throughput, seepage and incidents.

Hydrocarbon Spills

Hydrocarbons would be most likely to be spilt:

- In a catastrophic incident such as failure of a storage vessel;
- Around common usage areas such as refuelling facilities; or
- Spillages associated with ruptured hydraulics.

The location of a large, catastrophic event would likely be around fuel storage and handling facilities. Spillage around common usage areas also tends to be more frequent and can result in significant cumulative totals of spillage over a longer period. In locations of significant instant spillage (say > 100 L of hydrocarbons), immediate control measures to contain the spread of spilt hydrocarbon, care not to ignite the material, and a substantial clean up may be required.

Hydraulic hose and fitting failures will be more frequent, more widespread, but will generally result in smaller quantities of spillage.

Depth to groundwater around the mining and processing operational areas is expected to be 30 – 40 mbgl. Spillage would need to be significant (many thousands of litres) and un-noticed for a long period to appear in groundwater.

Emergency response training and procedures will include significant incidents such as fuel storage and handling failures and include control measures for any significant hydrocarbon spillage. Incident reporting procedures will include thresholds for hydrocarbon spillage designed to ensure that contamination from spilt hydrocarbons does not escape to contaminate groundwater. Areas of repeated spillage would be investigated, and if no immediate response is required, would be cleaned up at mine closure.

Hydrocarbon storage above 100,000 L is subject to the licencing requirements of the Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2007. Fuel storage at the mine site may exceed this threshold and be subject to a Dangerous Goods Licence. Areas of suspected or actual hydrocarbon contamination will be subject to the *Contaminated Sites Act 2000*.

Based on the above, it is considered unlikely that hydrocarbon spills would result in the contamination of the underlying groundwater systems.

Saline Water Leaks or Spills

Saline water pipelines will run from the borefield to the RO Plant, then from the RO Plant to the evaporation ponds. A rupture of these pipelines has the potential to seep into the surrounding soils if it were to occur, and may reach the underlying groundwater in extreme cases. Leak detection is proposed for these pipelines, which will trigger an automatic shut-down of the borefield or RO Plant feed. This will restrict the volume of saline water that would be released into the surrounding environment. Audalia will also investigate the option of containing a spill if it was to occur, by placing the pipes in a system of bunds and sumps designed to contain spillage. This option however may not be pursued along the whole length of the pipelines as the area likely to be affected by a spill may be less than the clearing of vegetation required to develop this containment infrastructure. The details of these systems are generally planned and managed via a Works Approvals under Part V of the EP Act (for the RO Plant, evaporation ponds and Process Plant) and a MP under the Mining Act. Additional mitigation measures are proposed in Section 9.6 to minimise the change and potential impact of a saline water pipeline spill.

9.5.5 Groundwater underlying the Haul Road Development Envelope

The proposal has a projected water demand of approximately 0.4 GL/yr (12.7 L/s) of groundwater for dust suppression purposes along the 74 km haul road and transfer depot.

Groundwater Abstraction and Drawdown

As described in Section 9.3.5, groundwater demand for the haul road and transfer area is expected to be approximately 0.4 GL/yr. Up to five water bores are planned to be established along the length of the haul road. The highest demand will be at the eastern end of the haul road to support dust control and water supply at the product transfer facility (GRM, 2020d).

Drawdown impacts associated with water supply bores installed along the haul road corridor are likely to be limited, due to the low yield requirement per bore and the large distance between bores. However, it is important to note that drawdown impacts will likely differ depending on the aquifer type, for example (from GRM, 2020d):

- Groundwater abstraction from palaeo-tributary aquifers typically result in drawdown extending laterally along the palaeo-tributary, with very limited leakage from the overlying clay aquitard. This typically results in minimal drawdown response in the shallow groundwater environment. Assuming similar permeability conditions to the Lefroy palaeo-tributary (GRM, 2020b), drawdown in the Cowan palaeo-tributary associated with a bore yield of 4 L/s over the 13 year Life of Mine (LoM) could potentially result in a drawdown of less than 1 m in the shallow groundwater environment;
- Groundwater abstraction from fractured rock aquifers typically extend laterally along the fracture orientation, with limited drawdown into the surrounding intact rock. Assuming similar hydraulic conditions to the fractured bedrock aquifers tested during the recent field investigations within the mining area (GRM, 2020b) drawdown associated with a bore yield of 4 L/s over the 13 year LoM could potentially result in a 1 m drawdown contour extending up to 1 km along strike from each fractured rock bore; and
- Groundwater abstraction from alluvial aquifers typically results in drawdown extending uniformly in all directions, which is usually recharged following rainfall events. This aquifer type was not assessed during recent field investigations by GRM (2020b). However previous experience suggests that the 1 m drawdown contour could extend 1 - 2 km from the bore depending on the aquifer thickness and pumping rate. Alluvial bores would likely provide lower salinity groundwater than the other two aquifer types. However the bore yields could diminish after prolonged periods of dry conditions if the aquifer storage is limited, although the yields would likely increase again following rainfall recharge.

Given the small water demand, the presence of multiple water sources, and regional examples of water extraction, it is expected that groundwater can be sourced from regional aquifers without resulting in a significant impact to these aquifers.

Hydrocarbon Spills

The storage or use of large volumes of hydrocarbons or chemicals is not expected to be required for the construction or operation of the haul road. The implementation of industry-standard mitigation measures (Section 9.6) is expected to ensure that spills are controlled, contained and cleaned up such that it would be unlikely to seep through to the underlying groundwater.

9.6 Mitigation

Audalia has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

9.6.1 Avoid

The following measures have been adopted to avoid impacts to inland waters;

1. The selected haul road route generally traverses the upper reaches of catchments, avoiding significant surface water flow crossings;
2. On-site processing is limited to beneficiation, which avoids the significant water demand associated with further onsite processing; and
3. Direct impacts to the upslope catchment of *M. aquilonaris* sub-populations have been avoided by relocating the pit boundaries.

9.6.2 Minimise

The following mitigation measures are proposed to ensure that direct and indirect impacts to inland waters are minimised:

1. **Obtain and comply with Works Approval and Licence issued under Part V of the EP Act**. A Works Approval and Licence will be required for the Proposal, specifically for the Process Plant, TSF, RO Plant, evaporation ponds, sewage treatment plant and landfill. These items present the highest surface water and groundwater pollution risks for the Proposal. Therefore the Works Approval and Licence is the primary mechanism for ensuring the design and operation of the Proposal is conducted in a manner that minimises pollution impacts to inland waters. The Works Approval and Licence will ensure that the following mitigation measures are implemented at a minimum:
    a. Complete further groundwater investigations and modelling. This will determine the long term yields and the required borefield configuration necessary for the Proposal consistent with the requirements for licencing of groundwater extraction and to enable the implications of seepage from the TSF and evaporations ponds;
    b. Incorporate seepage controls into the TSF design if required. This will be conducted if detailed investigations and modelling indicates seepage likely to raise naturally hypersaline groundwater into the root zone of native vegetation downslope from the TSF;
    c. Monitor TSF embankment piezometers;
    d. Manage water pressure levels in TSF embankments to maintain required factors of safety;
    e. Monitor groundwater levels and quality down-gradient of the TSF. Monitoring bores will be installed down-gradient of the TSF. Cut-off and diversion drains will be constructed at the base of the TSF embankment and around the upslope edge of the TSF respectively. The monitoring information will be used to determine whether any mounding is occurring, and any seepage losses. Suitable baseline bores will also be monitored to allow an appropriate comparison;
    f. Install cut-off bores, sumps and / or trenches and pump the water back the source (TSF or evaporation pond) if the monitoring described above either:

   i. Identifies sustained mounding that is approaching levels where it could interact with vegetation, or appear at soil surface; or
   ii. Identifies poor water quality that is significantly different to the natural groundwater range and may contaminate GDEs or water supply;

   g. Routinely inspect the condition and performance of pond walls, pipelines, containment systems and internal drainage structures, to ensure they are in acceptable condition and / or operating appropriately;
   h. Sufficient freeboard will be included in the TSF and evaporation pond wall designs to prevent overtopping;
   i. The TSF and evaporation pond walls will be engineered to hold the full capacity of the tailings / RO brine and a significant rainfall event;
   j. The TSF and evaporation pond walls will be engineered and constructed according to specifications;
   k. The integrity of the TSF and evaporation pond walls will be assessed during regular inspections;
   l. The following controls will be implemented to minimise the risk of impact from unintentional tailings or saline water pipeline spills:
      i. Pipelines will be fitted with leak detection;
      ii. Water flows will be shut off if leaks are detected;
      iii. Pipelines will be inspected regularly, especially during extreme heat or fire events;
      iv. Pipelines will be located off access road surfaces;
      v. If pipelines have to cross access roads then they will be buried;
      vi. Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence;
   m. Sewage will be treated and discharged to a dedicated irrigation area that is appropriately sized for the predicted volumes;
   n. The landfill will be developed and operated in accordance with the Environmental Protection (Rural Landfill) Regulations (Government of WA, 2002);

2. **Obtain and comply with a Mining Proposal issued under the Mining Act**. A MP will be required for the Proposal, for all works apart from minor works that may occur within MRWA tenure. The MP is the primary mechanism for ensuring the design of the TSF and evaporation ponds are safe and stable, such that the risk of embankment breaches and overtopping is minimised. The MP will ensure that the following mitigation measures are implemented at a minimum:
   a. A Detailed TSF Design Report is approved prior to construction;
   b. A TSF Operating Manual is approved prior to operation;
   c. Geotechnical stability standards are met;
   d. Geotechnical monitoring and inspections are conducted; and
   e. Mitigation measures previously listed in item 1 (for Works Approval and Licences);
3. **Obtain a 5C Licence under the RIWI Act if groundwater sources are from a confined or semi-confined aquifer**;
4. **Implement the following measures to minimise the risk and impact of hydrocarbon spills:**
   a. Hydrocarbons will be stored either within a bunded area or within self-bunded tanks;

   b. All spills will be controlled, contained and cleaned up as soon as practicable;
   c. Service vehicles will be fitted with spill kits;
   d. Spill kits will be located at all workshop and fuel storage areas;
   e. Environmental incident recording, investigation and reporting system; and
5. **All road surface water crossings will be designed to minimise the potential for erosion and sedimentation of surface waters**:
   a. Haul Road crossings will be constructed as per the recommendations in GRM (2020c; Appendix 8.3) and by adopting the principles from 'Field guide for erosion and sediment control maintenance practices' (NSW Environment and Heritage, 2012);
   b. Visual monitoring will be conducted after flood events to ensure that there is no ponding or other flow restrictions in the vicinity of the drainage crossings. The drainage structures are to be revised, reinstalled or redesigned if flow restrictions are noted;
6. **Comply with Water Quality Protection Guidelines and guidance notes,** particularly in relation to the storage and use of hydrocarbons and other harmful chemicals, the design and operation of vehicle maintenance areas and facilities, the siting and operation of wastewater treatment systems, and the handling and storage of other waste materials, including contaminated soils**.**

9.6.3 Rehabilitate

At the completion of the Proposal the site will be rehabilitated. One of the planned outcomes will be to reinstate inland water regimes. An interim MCP has been prepared to accompany this ERD (Appendix 4) which was developed according to DMIRS Guidelines (2020a; 2020b). The MCP describes the rehabilitation and closure of the Proposal, and associated management and monitoring proposed during the closure phase including**:**

- Materials balance for closure and rehabilitation demonstrating the quantities, availability and management for all rehabilitation materials;
- Identified knowledge gaps to be filled prior to closure;
- Closure tasks for the TSF and evaporation ponds domains; and
- Completion criteria, monitoring and reporting during closure.

The key rehabilitation measures from the MCP that relate to inland waters are summarised below:

1. The haul road will either be retained with a new owner agreed to take responsibility, or will be rehabilitated with any watercourse crossing structures removed;
2. The mining area will be landformed, with post-mining drainage constructed to required standards;
3. The mining area will be revegetated with local native species;
4. All infrastructure will be removed; and
5. All surface water drainage systems will be reinstated.

The MCP will be submitted to DMIRS for assessment and approval under the Mining Act prior to the construction of the Proposal and will be reviewed and revised every three years.

9.7 PREDICTED OUTCOME

The EPA's environmental objective for this factor is "maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected" (EPA, 2018a).

The Proposal has been designed to ensure that hydrological regimes are maintained. GRM (2020b) have proposed the design of creek crossings along the haul road to ensure flows are maintained, and Audalia have committed to implementing these recommendations. The mine will require some diversions of surface water flows however these flow lines are high in the catchment and flow volumes are unlikely to be large through these areas. The drainage diversions are therefore expected to be appropriate for maintaining the hydrological regimes through the Mine DE.

Audalia has revised its mine plan to avoid any direct disturbance upslope of any existing *M. aquilonaris* sub-populations, therefore the Proposal will not reduce any surface water flows into these sub-populations. 0.56 ha of direct disturbance will be required upstream of optimal habitat for *M. aquilonaris*, which will reduce the surface water flows into these areas. This reduction in the catchment is considered unlikely to reduce the viability of the optimal habitat, as the sub-populations for this species lie across catchment divides (Figure 63), indicating that the species is unlikely to be reliant on upslope surface water runoff for survival.

The Proposal is not expected to significantly impact the quality of groundwater or surface water. Tailings seepage is benign and fresh, and there is saline - hypersaline groundwater throughout the Mine DE and no beneficial users of this resource. Leaks and spills of tailings or saline water are able to be managed such that impacts are rare and restricted in extent if they were to occur. Erosion and hydrocarbon spills are able to be mitigated such that significant impacts are unlikely.

The key risks to the quality of inland waters is pollution from the Process Plant, TSF, RO Plant, evaporation ponds, saline water pipelines, wastewater treatment plant and landfill. The design and operation of all of these items will be regulated under Part V of the EP Act and the Mining Act.

The implementation of design and operations mitigation measures, and regulation under Part V of the EP Act and the Mining Act, are expected to ensure that the Proposal does not significantly impact this factor. The EPA objective for this factor is therefore able to be met.

10 OTHER ENVIRONMENTAL FACTORS – GREENHOUSE GAS EMISSIONS

The EPA Objective for this key environmental factor is to reduce net greenhouse gas (GHG) emissions in order to minimise the risk of environmental harm associated with climate change (EPA, 2020f).

The EPA originally identified that Air Quality was an 'other environmental factors or matters' relevant to this Proposal, particularly relating to GHG emissions. Since this decision the EPA has released the 'Environmental Factor Guideline for GHG Emissions' (EPA, 2020f) and GHG Emissions has replaced Air Quality as the 'other environmental factors or matters' relevant to the Proposal.

The following work was required to be addressed during the environmental review and discussed in this ERD:

- Provide an estimate of the expected annual Scope 1 (direct) GHG emissions from the Proposal; and
- Provide details of any mitigation measures designed to avoid or minimise GHG emissions during the implementation of the Proposal.

10.1 ESTIMATE OF SCOPE 1 GREENHOUSE GAS EMISSIONS

Just Design Engineering (JD Engineering) (2019) was engaged by Audalia to assess the expected GHG emissions from the Proposal's entire life cycle. The Proposal will have direct (scope 1) one-off construction emissions and longer term emissions as a result of operational activities. No Scope 2 (energy indirect) emissions were considered given that there is no purchase of off-site electricity.

The principal source of GHG from the Proposal is the combustion of diesel for power production, transport and ore beneficiation. Emission sources and activity data description are provided in Table 73 according to the mine site development plan.

Table 73: GHG sources and activities

Emission Activity	Description
Diesel consumption for construction	Diesel consumption during construction phase
Diesel consumption for mining	Diesel for mining operation, i.e. excavation, movement of ore and waste rock
Diesel consumption for power generation	Electricity power for ore processing and infrastructures on site
Diesel consumption for concentrate transportation	Concentrate haulage from site to Esperance Port
Wastewater from accommodation	Methane gas emitted from Wastewater Treatement Plant
Land use change	650 ha land disturbance

An estimate of the expected annual Scope 1 GHG emissions from the Proposal was calculated by JD Engineering (2019), as shown in Table 74. Table 74 includes the total of carbon dioxide equivalent (CO_2-e) emissions in tonnes estimated for each year and phase of the Proposal. An average of 55,456 t of CO_2-e are estimated to be produced per year over the 13 year life of the Proposal. The Proposal is predicted to increase WA's GHG emissions on average by approximately only 0.07% per annum, when compared to the State's 83.4 Mt of CO_2-e for 2013-14 provided in the EPA guideline (EPA, 2020e) and is therefore not considered to be a significant contributor of GHG emissions.

Table 74: Annual GHG emissions for the Proposal

Year / Phase	Land Use Change	Construction	Operation	Decommissioning	Total annual tCO_2-e
Construction (Year 0)	35,555	22,591	-	-	58,146
Year 01 - 13	-	-	50,288	-	50,288
Closure (Year 14)	-	-	-	9,036	9,036

10.2 Mitigation

Audalia has mitigated the potential impacts to this factor according to the mitigation hierarchy: avoid, minimise, rehabilitate, offset. Offsets are not expected to be required for this factor.

10.2.1 Avoid

Audalia has investigated several options for power supply for the Proposal, including renewable sources. Wind and solar power could provide some of the power requirements of the Proposal, however this would require additional clearing within an area with noted high ecological value. Audalia has adopted to avoid vegetation clearing wherever practicable given these constraints. Given the relatively short mine life and the clearing restrictions discussed above, the use of renewable energy was not considered to be viable for the Proposal.

10.2.2 Minimise

The following mitigation measures are proposed to avoid or minimise GHG emissions during the implementation of the Proposal:

1. **Utilise heavy haulage trucks along the haul road**. The private haul road allows Audalia to run larger trucks between the mine and the Coolgardie to Esperance Highway. This improves the efficiency of the ore transport and in turn reduces GHG emissions;
2. **Maximise electrical efficiency**. The following activities will be managed to maximise electrical efficiency and therefore minimise GHG emissions:
   a) Regular monitoring of electrical load on the processing equipment and investigation whenever the load falls outside optimal parameters;
   b) Regular maintenance and inspection of processing equipment to keep them in high efficiency;
   c) Regular electrical calibration checks on the processing equipment;
   d) Use of high efficiency electrical motors throughout the mine site; and
   e) Use of variable speed drive pumps, compressors and other processing equipment.
3. **Maximise diesel efficiency.** The following activities will be implemented to minimise the use of diesel:

a) Haul truck scheduling, routing and idling times will be optimised through the sophisticated design to minimise the amount of diesel consumed;
b) Pit access ramps will be designed to limit the amount of effort required for fully-laden trucks to climb;
c) Haul roads will be compacted to reduce rolling resistance;
d) The ramp and haul road design will be optimised to minimise the amount of distance haul trucks need to travel;
e) Truck maintenance will be scheduled regularly, including tyre condition monitoring; and
f) Consideration of fuel efficiency of haul trucks will be undertaken during procurement.

10.2.3 REHABILITATE

At the completion of the Proposal mine operation plant and associated facilities will be closed and rehabilitated. No more GHG emissions are expected to be produced at the completion of the rehabilitation phase.

10.3 PREDICTED OUTCOME

The proposal is predicted to produce an average of 55,456 t CO_2-e of Scope 1 GHG emissions per year over the 13-year mine life. This equates to only 0.07% of the predicted annual GHG emissions in WA. Audalia is committed to minimise GHG emissions through the implementation of the mitigation measures described in Section 10.2.

Based on the assessment above, the Proposal is not considered to have a significant impact on this factor.

11 OFFSETS

Offsets are the last of the four steps in the mitigation hierarchy (Avoid, Minimise, Rehabilitate and Offset). They are only applied to counterbalance residual significant impacts when the other steps have already been applied to a Proposal.

Audalia commissioned numerous environmental surveys and studies for the Proposal. The surveys determined that there were key environmental values that required protection, including significant flora, the Bremer Range Vegetation Complexes PEC and the proposed Bremer Range Nature Reserve.

Audalia assessed the findings of the surveys and studies and made significant changes to the Proposal design. Some of these changes carried a significant cost (such as reducing the size of the Vesuvius mine pit) – affecting the unit costs of the Proposal. Changes were also made to avoid and minimise construction and operational impacts, such as implementing strict clearing controls, dust mitigation and surface water drainage controls.

The application of these avoidance and minimisation mechanisms in Proposal design and operations has meant that impacts to many key environmental values have been avoided or significantly reduced. Audalia understands that this conclusion is in part based on studies and modelling, and as such monitoring has been committed to in order to verify the study and model outputs.

11.1 WA Environmental Offsets Guidelines

The WA Environmental Offsets Guidelines (EPA, 2014) states:

> "In general, significant residual impacts include those that affect rare and endangered plants and animals (such as declared rare flora and threatened species that are protected by statute), areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreements (such as Ramsar listed wetlands) and areas that are already defined as being critically impacted in a cumulative context. Impacts may also be significant if, for example, they could cause plants or animals to become rare or endangered, or they affect vegetation which provides important ecological functions".

Audalia has assessed the residual impacts of the Proposal against the residual impact significance model provided in the WA Environmental Offsets Guidelines (EPA, 2014). The findings of this assessment is provided in Table 75.

Table 75: Assessment against residual impact significant model

Relevant Part IV Environmental Factors	Vegetation and Flora						
				Terrestrial Fauna			
Part V Clearing Principles	**c -** Rare flora	**d -** TECs	**e -** Remnant vegetation	**f -** Wetlands and waterways	**h -** Conservation areas	**a -** High biological diversity	**b -** Habitat for fauna
Residual impact that is environmentally unacceptable and cannot be offset	No residual impacts are considered to meet this criteria						
Significant residual impacts that will require an offset – *all significant residual impacts to species and ecosystems are protected by statute or where the cumulative impact is already at a critical level*	It is considered likely that the residual impacts to *M. aquilonaris* would meet this criteria	No residual impacts are considered to meet this criteria - no TECs were recorded within the DEs	No residual impacts are considered to meet this criteria – all remaining vegetation will have 97% or more of their pre-European extent remaining	No residual impacts are considered to meet this criteria as no wetlands or waterways that are protected by statute lie within the DEs or would be indirectly impacted by the Proposal	No residual impacts are considered to meet this criteria as no conservation areas that are protected by statute lie within the DEs or would be indirectly impacted by the Proposal	No residual impacts are considered to meet this criteria, while the Great Western Woodland and specifically the Bremer Range are known to have high ecological significance the residual impacts on these areas are not considered significant given the area of intact habitat will remain outside the DEs.	No residual impacts are considered to meet this criteria as no restricted habitats for Threatened Fauna will be impacted and suitable intact habitat will remain outside the DEs.
Significant residual impacts that may require an offset – *any significant residual impacts to potentially threatened species and ecosystems, areas of high environmental value or where the cumulative impact may reach critical levels if not managed*	It is considered likely that the residual impacts to *Eucalyptus rhomboidea* and *Stenanthemum bremerense* would meet this criteria.	It is considered likely that the residual impacts to the Bremer Range Vegetation Complexes PEC would meet this criteria.	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria – refer above	It is considered likely that the residual impacts to the proposed Bremer Range Nature Reserve would meet this criteria.	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria – refer above

As described in Table 75, based on the findings of the EIA in this ERD, Audalia considers that the Proposal's residual impacts to *M. aquilonaris*, *E. rhomboidea*, *S. bremerense*, the Bremer Range Vegetation Complexes PEC and the proposed Bremer Range Nature Reserve may be considered significant and require offsets.

During the assessment Audalia noted some uncertainty about whether the Proposal impacts the Bremer Range Vegetation Complexes PEC and the proposed Bremer Range Nature Reserve may be considered significant and require offsets. Constituted a significant residual impact that would require offsets. The WA Environmental Offsets Guidelines (EPA, 2014) notes that:

> "There may be cases where there is some uncertainty about whether a significant residual impact will occur, and/or the extent of the impact. An offset may apply in some cases based on an assessment of the risk using a normal risk-based approach, that is considering the 'likelihood' of the impact occurring and the 'consequences' of the impact if it did occur, based on the evidence and information available. Offsets would normally only be applied in cases where there was a significant risk that the impact was likely to occur and there was likely to be a significant consequence".

The indirect impacts described in this ERD are deliberately conservative (appropriately based on the precautionary principle) however it is unlikely that the full scale of indirect impacts would occur. Based on the above, Audalia has committed to ongoing monitoring that will inform and ultimately verify the scale of these residual indirect impacts. The key monitoring is considered to be the dust deposition monitoring and the ongoing Significant Flora Monitoring Programme.

The dust deposition monitoring and Significant Flora Monitoring Programme are committed to in this ERD in Section 5. These monitoring programmes are designed to monitor and compare dust deposition against model predictions, and monitor the health of significant flora populations over the life of the Proposal.

11.2 WA Offsets Template

Audalia has completed a WA Offsets Template as per the requirements of the WA Environmental Offsets Guideline (EPA, 2014), provided in Table 76.

Table 76: WA offsets policy template

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
M. aquilonaris **(T)** – Disturbance of 1.51 ha of sub-optimal habitat within the critical habitat boundary Reduction in flora and/or habitat health as a result of indirect impacts Disturbance and indirect impacts to pollinator habitat	**Avoid**: DEs were revised to avoid: • All current individuals • All current areas of occupancy (sub-populations) • All optimal habitat • All catchment areas upslope of current areas of occupancy **Minimise**: • Implement industry best practice management measures for flora and vegetation • Ensure ground disturbance does not exceed the 1.51 ha of sub-optimal habitat limit proposed in the Key Proposal Characteristics • Implement additional ground disturbance measures for any ground disturbance within critical habitat • Implement the Dust Management Plan • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes • Implement additional controls upslope of *M. aquilonaris* critical habitat • Implement Significant Flora Monitoring Programme • Conduct an additional *M. aquilonaris* pollinator survey during peak flowing season	Direct disturbance not able to be rehabilitated as disturbance is limited to mine pit and abandonment bund. Surrounding vegetation to be rehabilitated with stripped topsoil and seeded if required.	<u>Can the environmental values be rehabilitated/Evidence?</u> No - disturbance is limited to mine pit and abandonment bund which cannot be rehabilitated back to previous value <u>Operator experience in undertaking rehabilitation?</u> N/A <u>What is the type of vegetation being rehabilitated?</u> N/A <u>Time lag?</u> N/A <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> N/A	<u>Extent</u> 1.51 ha of sub-optimal habitat and potential indirect impacts to 2.91 ha of critical habitat <u>Quality</u> • Vegetation is in good to very good condition • Sub-optimal habitat <u>Conservation Significance</u> Threatened species <u>Land Tenure</u> Mining Act tenure <u>Time Scale</u> N/A According to the significance framework, residual impact is considered to be significant because a specially protected species under the BC Act is impacted.	Provision of funding and support (to address any DMIRS concerns) for the development of a conservation reserve or other protected area (i.e. under Section 19 of the Mining Act) for *M. aquilonaris* sub-populations 1a, 1d and 1e, and surrounding critical habitat extents.	Medium – DMIRS consent not yet obtained and some sub-population areas lie outside Audalia's Mining Act tenure	<u>Can the values be defined and measured?</u> Yes - value to *M. aquilonaris* can be measured <u>Operator experience/Evidence?</u> DBCA will manage the land <u>What is the type of vegetation being revegetated?</u> N/A	Secures critical habitat upon agreement – no time delay	Offset would ensure protection of 76% of known individuals across three of the five current sub-populations, as well as improve / maintain the quality of all current sub-populations and Bremer Range, and expand current knowledge on the species.
					Revegetation of previously disturbed vegetation within the critical habitat boundary (access tracks).	Low - sites occur on Audalia Mining Act tenure and UCL	<u>Can the values be defined and measured?</u> Yes - value to *M. aquilonaris* can be measured <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> Previously disturbed vegetation within the critical habitat boundary (access tracks).	Expected to be several years before any new *M. aquilonaris* individuals become established (may be reliant on fire events)	
					On ground management within critical habitat (weeds and feral fauna)	Low - sites occur on Audalia Mining Act tenure and UCL	<u>Can the values be defined and measured?</u> Yes - value to *M. aquilonaris* can be measured <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A	No time delay, can be implemented immediately	
					On ground management of broader Bremer Range	Low – Bremer Range occurs on UCL	<u>Can the values be defined and measured?</u> No - value to *M. aquilonaris* cannot be clearly measured <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A	No time delay, can be implemented immediately	

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
					Ongoing research: • Ongoing germination trials • Annual plant counts • Regional searches after fire events • Sub-population health monitoring • Rehabilitation trials	Low - sites occur on Audalia Mining Act tenure and UCL	<u>Can the values be defined and measured?</u> No - value to *M. aquilonaris* cannot be measured in this case <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A	Expected to be several years before the results provide data that is useful for the protection of the species.	
E. rhomboidea **(P4)** – Disturbance of 768 individuals and 0.4 ha of population extent Reduction in flora and/or habitat health as a result of indirect impacts	**Avoid**: DEs were revised to avoid more than 79% of records within the study areas **Minimise**: • Implement industry best practice management measures for flora and vegetation • Ensure ground disturbance does not exceed the limit proposed in the Key Proposal Characteristics: 0.4 ha of population extent • Conduct additional significant flora searches of final proposed mine and infrastructure disturbance footprints • Prepare and implement a Mine and Infrastructure Plan • Implement additional ground disturbance measures for any ground disturbance within population boundaries • Implement the Dust Management Plan • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	Direct disturbance not able to be rehabilitated as disturbance is limited to mine pit and abandonment bund. Surrounding vegetation to be rehabilitated with stripped topsoil and seeded if required.	<u>Can the environmental values be rehabilitated/Evidence?</u> No - disturbance is limited to mine pit and abandonment bund which cannot be rehabilitated back to previous value <u>Operator experience in undertaking rehabilitation?</u> N/A <u>What is the type of vegetation being rehabilitated?</u> N/A <u>Time lag?</u> N/A <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> N/A	<u>Extent</u> 768 individuals and 0.4 ha of population extent. Potential indirect impacts to 430 individuals <u>Quality</u> Vegetation is in good to very good condition <u>Conservation Significance</u> Priority 4 species <u>Land Tenure</u> Mining Act tenure <u>Time Scale</u> N/A According to the significance framework, residual impact is considered to be significant because a potential future specially protected species under the BC Act is impacted.	Successful translocation of all impacted individuals (numbers to be based on pre-clearance survey) to rehabilitation areas	Medium – suitable germination trials not yet completed however this species is expected to be able to be germinated (Western Botanical, 2018)	<u>Can the values be defined and measured?</u> Yes - value can be measured <u>Operator experience/Evidence?</u> Varied – DBCA may undertake the offset if preferred, or Audalia consultants or local land care groups may be engaged <u>What is the type of vegetation being revegetated?</u> Woodland / shrubland	Expected to be ten years before any new individuals / populations become established	Offset would ensure protection of two of the six known local sub-populations, , as well as improve / maintain the quality of the current sub-populations and Bremer Range, and expand current knowledge on the species.
					Provision of funding and support (to address any DMIRS concerns) for the development of a conservation reserve or other protected area (i.e. under Section 19 of the Mining Act) for two *E. rhomboidea* sub-populations and surrounding critical habitat extents.	Medium – DMIRS consent not yet obtained and some sub-population areas lie outside Audalia's Mining Act tenure	<u>Can the values be defined and measured?</u> Yes - value to *Eucalyptus rhomboidea* can be measured <u>Operator experience/Evidence?</u> DBCA will manage the land <u>What is the type of vegetation being revegetated?</u> N/A	Secures critical habitat upon agreement – no time delay	
					On ground management (weeds and feral fauna) of local populations	Medium – some local populations occur outside of Audalia Mining Act tenure	<u>Can the values be defined and measured?</u> Yes - value can be measured <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A	No time delay, can be implemented immediately	
					On ground management of	Low – Bremer Range occurs on UCL	<u>Can the values be defined and measured?</u>	No time delay, can be implemented immediately	

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
	• Implement additional controls upslope of population boundaries				broader Bremer Range		No - value cannot be clearly measured <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A		
					Ongoing research: • Ongoing germination trials • Annual plant counts • Regional searches after fire events • Population health monitoring • Rehabilitation trials • Genetic studies	Low – research sites would be located on Audalia Mining Act tenure and UCL	<u>Can the values be defined and measured?</u> No - value cannot be measured in this case <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A	Expected to be several years before the results provide data that is useful for the protection of the species.	
***S. bremerense* (P4)** – Disturbance of 2,049 individuals and 21 ha of population extent Reduction in flora and/or habitat health as a result of indirect impacts	**Avoid**: DEs were revised to avoid more than 88% of records within the study areas **Minimise**: • Implement industry best practice management measures for flora and vegetation • Ensure ground disturbance does not exceed the limit proposed in the Key Proposal Characteristics: 21 ha of population extent • Conduct additional significant flora searches of final proposed mine and infrastructure disturbance footprints • Prepare and implement a Mine and Infrastructure Plan • Implement additional ground disturbance measures for any ground disturbance within population boundaries	Direct disturbance not able to be rehabilitated as disturbance is limited to mine pit and abandonment bund. Surrounding vegetation to be rehabilitated with stripped topsoil and seeded if required.	<u>Can the environmental values be rehabilitated/Evidence?</u> No - disturbance is limited to mine pit and abandonment bund which cannot be rehabilitated back to previous value <u>Operator experience in undertaking rehabilitation?</u> N/A <u>What is the type of vegetation being rehabilitated?</u> N/A <u>Time lag?</u> N/A <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> N/A	<u>Extent</u> 2,049 individuals and 21 ha of population extent. Potential indirect impacts to 1,379 individuals <u>Quality</u> Vegetation is in good to very good condition <u>Conservation Significance</u> Priority 4 species <u>Land Tenure</u> Mining Act tenure <u>Time Scale</u> N/A According to the significance framework, residual impact is considered to be significant because a potential future specially protected species under the BC Act is impacted.	Successful translocation of all impacted individuals (numbers to be based on pre-clearance survey) to rehabilitation areas	Medium – suitable germination trials not yet completed however this species is expected to be able to be germinated (Western Botanical, 2018)	<u>Can the values be defined and measured?</u> Yes - value can be measured <u>Operator experience/Evidence?</u> Varied – DBCA may undertake the offset if preferred, or Audalia consultants or local land care groups may be engaged <u>What is the type of vegetation being revegetated?</u> Woodland / shrubland	Expected to be several years before any new individuals / populations become established	Offset would ensure protection of 12 of the 25 known local sub-populations,, as well as improve / maintain the quality of the current sub-populations and Bremer Range, and expand current knowledge on the species.
					Provision of funding and support (to address any DMIRS concerns) for the development of a conservation reserve or other protected area (i.e. under Section 19 of the Mining Act) for 12 *S. bremerense* sub-populations and surrounding critical habitat extents.	Medium – DMIRS consent not yet obtained and some sub-population areas lie outside Audalia's Mining Act tenure	<u>Can the values be defined and measured?</u> Yes - value to *Stenanthemum bremerense* can be measured <u>Operator experience/Evidence?</u> DBCA will manage the land <u>What is the type of vegetation being revegetated?</u> N/A	Secures critical habitat upon agreement – no time delay	
					On ground management (weeds and feral	Medium – some local populations occur outside	<u>Can the values be defined and measured?</u> Yes - value can be measured	No time delay, can be implemented immediately	

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
	• Implement the Dust Management Plan • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes • Implement additional controls upslope of population boundaries				fauna) of local populations	of Audalia Mining Act tenure	<u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A		
					On ground management of broader Bremer Range	Low – Bremer Range occurs on UCL	<u>Can the values be defined and measured?</u> No - value cannot be clearly measured <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A	No time delay, can be implemented immediately	
					Ongoing research: • Ongoing germination trials • Annual plant counts • Regional searches after fire events • Population health monitoring • Rehabilitation trials • Genetic studies	Low – research sites would be located on Audalia Mining Act tenure and UCL	<u>Can the values be defined and measured?</u> No - value cannot be measured in this case <u>Operator experience/Evidence?</u> Varied – DBCA may undertake some of the offset, Audalia consultants or local land care groups may also be engaged <u>What is the type of vegetation being revegetated?</u> N/A	Expected to be several years before the results provide data that is useful for the protection of the species.	
Other Priority Flora – Disturbance of: • 10,021 individuals of *Acacia mutabilis* subsp. *Stipulifera* • 876 individuals of *Hakea pendens* • 1,150 individuals of *Teucrium diabolicum* Reduction in flora and/or habitat health as a result of indirect impacts	**Avoid**: DEs were revised to avoid: • More than 96% of *Acacia mutabilis* subsp. *stipulifera* (P3) records within the study areas • More than 40% of *Hakea pendens* (P3) records within the study areas • More than 87% of *Teucrium diabolicum* (P3) records within the study areas **Minimise**: • Implement industry best practice management measures for flora and vegetation	Vegetation to be rehabilitated with stripped topsoil and seeded with impacted species if required and suitable. The mine pit slopes and abandonment bund are not able to be rehabilitated.	<u>Can the environmental values be rehabilitated/Evidence?</u> Partially - disturbance of mine pit and abandonment bund cannot be rehabilitated back to previous value, however remaining disturbance (>600 ha) is expected to be able to be rehabilitated such that suitable habitat for these species would be present <u>Operator experience in undertaking rehabilitation?</u> Audalia will utilise experienced operators to conduct the rehabilitation works <u>What is the type of vegetation being rehabilitated?</u> Woodland and shrubland <u>Time lag?</u>	No					

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
	• Conduct additional significant flora searches of final proposed mine and infrastructure disturbance footprints • Prepare and implement a Mine and Infrastructure Plan • Implement the Dust Management Plan • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes		Expected to be up to ten years before any rehabilitation areas become established Credibility of the rehabilitation proposed (evidence of demonstrated success) There are very few rehabilitation sites in the area however mine site rehabilitation methods are well established						
Proposed Bremer Range Nature Reserve – Up to 309 ha of disturbance Reduction in vegetation health as a result of indirect impacts	**Avoid**: Not able to avoid impacts **Minimise**: • Implement industry best practice management measures for flora and vegetation • Conduct additional significant flora searches of final proposed mine and infrastructure disturbance footprints • Prepare and implement a Mine and Infrastructure Plan • Implement the Dust Management Plan • Ensure all surface water crossings are designed to minimise the potential for erosion or sedimentation of downstream vegetation • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	• All disturbance areas apart from the mine pit and TSF slopes will be will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated • Other Priority Flora will be included in the rehabilitation seed mix if seed is available and germination is likely to be successful • Flowering plants will be included in seeding to ensure pollinator habitat is adequately reinstated • All depressions will be shaped to prevent the formation of new semi-permanent water sources • All surface water drainage diversions will be rehabilitated to a natural form • All surface water crossings will be reinstated by removing drainage infrastructure and reshaping as required	Can the environmental values be rehabilitated/Evidence? Partially - disturbance of mine pit and abandonment bund cannot be rehabilitated back to previous value, however remaining disturbance (>260 ha) is expected to be able to be rehabilitated such that the values of the reserve is reinstated Operator experience in undertaking rehabilitation? Audalia will utilise experienced operators to conduct the rehabilitation works What is the type of vegetation being rehabilitated? Woodland and shrubland Time lag? Expected to be up to ten years before any rehabilitation areas become established Credibility of the rehabilitation proposed (evidence of demonstrated success) There are very few rehabilitation sites in the area however mine site rehabilitation methods are well established	Extent 309 ha (0.61% of extent) Quality Vegetation is in good to very good condition Conservation Significance Proposed nature reserve Land Tenure Mostly UCL Time Scale 13 – 23 years According to the significance framework, residual impact is considered to be significant because a proposed nature reserve is impacted.	Provision of funding and support (to address any DMIRS concerns) for the development of a conservation reserve or other protected area (i.e. under Section 19 of the Mining Act) over 767.7 ha of the Proposed Bremer Range Nature Reserve.	Medium – DMIRS consent not yet obtained and some of the proposed area lie outside Audalia's Mining Act tenure	Can the values be defined and measured? Yes - value to Proposed Bremer Range Nature Reserve can be measured Operator experience/Evidence? DBCA will manage the land What is the type of vegetation being revegetated? N/A	Secures area upon agreement – no time delay	Offset would ensure additional funding is available to preserve the values of the proposed Nature Reserve and protect 767.7 ha (1.52% of extent).
					On ground management, including rehabilitation of historic disturbance on closed mining tenements	Low – occurs primarily on UCL	Can the values be defined and measured? Yes - value can be measured Operator experience/Evidence? Varied – Audalia proposes to fund DBCA to undertake the offset, however Audalia consultants or local land care groups may also be engaged What is the type of vegetation being revegetated? N/A	No time delay, can be implemented immediately	
Bremer Range Vegetation Complexes PEC - 285 ha of disturbance Reduction in PEC health as a result of indirect impacts	**Avoid**: Not able to avoid impacts **Minimise**: As listed for Proposed Bremer Range Nature Reserve above	As listed for Proposed Bremer Range Nature Reserve above	Can the environmental values be rehabilitated/Evidence? Partially - disturbance of mine pit and abandonment bund cannot be rehabilitated back to previous value, however remaining disturbance (>235 ha) is expected to be able to	Extent 285 ha (0.32% of extent) Quality Vegetation is in good to very good condition	Provision of funding and support (to address any DMIRS concerns) for the development of a conservation reserve or other protected area (i.e.	Medium – DMIRS consent not yet obtained and some of the proposed area lie outside	Can the values be defined and measured? Yes - value to Bremer Range Vegetation Complexes PEC can be measured Operator experience/Evidence? DBCA will manage the land	Secures area upon agreement – no time delay	Offset would ensure additional funding is available to preserve the values of the PEC and protect 767.7 ha (1.51% of extent)..

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
			be rehabilitated such that the values of the PEC is reinstated Operator experience in undertaking rehabilitation? Audalia will utilise experienced operators to conduct the rehabilitation works What is the type of vegetation being rehabilitated? Woodland and shrubland Time lag? Expected to be up to ten years before any rehabilitation areas become established Credibility of the rehabilitation proposed (evidence of demonstrated success) There are very few rehabilitation sites in the area however mine site rehabilitation methods are well established	Conservation Significance PEC Land Tenure Mostly UCL Time Scale 13 – 23 years According to the significance framework, residual impact is considered to be significant because a proposed nature reserve is impacted.	under Section 19 of the Mining Act) over 767.7 ha of the Bremer Range Vegetation Complexes PEC.	Audalia's Mining Act tenure	What is the type of vegetation being revegetated? N/A		
					On ground management, including rehabilitation of historic disturbance on closed mining tenements	Low – PEC primarily occurs on UCL	Can the values be defined and measured? Yes - value can be measured Operator experience/Evidence? Varied – Audalia proposes to fund DBCA to undertake the offset, however Audalia consultants or local land care groups may also be engaged What is the type of vegetation being revegetated? N/A	No time delay, can be implemented immediately	
Locally significant vegetation - 544 ha of disturbance across five of the locally significant floristic communities	**Avoid**: DEs were revised to avoid: • Locally significant floristic communities HS-MWS1 and HS-MWS3 • More than 58% of all locally significant floristic communities **Minimise**: • Implement industry best practice management measures for flora and vegetation • Prepare and implement a Mine and Infrastructure Plan • Implement the Dust Management Plan • Ensure all surface water crossings are designed to minimise the potential for erosion or sedimentation of downstream vegetation • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	As listed for Proposed Bremer Range Nature Reserve above	Can the environmental values be rehabilitated/Evidence? Partially - disturbance of mine pit and abandonment bund cannot be rehabilitated back to previous value, however remaining disturbance (>505 ha) is expected to be able to be rehabilitated such that the values of the locally significant vegetation is reinstated Operator experience in undertaking rehabilitation? Audalia will utilise experienced operators to conduct the rehabilitation works What is the type of vegetation being rehabilitated? Woodland and shrubland Time lag? Expected to be up to ten years before any rehabilitation areas become established Credibility of the rehabilitation proposed (evidence of demonstrated success) There are very few rehabilitation sites in the area however mine site rehabilitation methods are well established	No					

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
Malleefowl and associated habitat - Up to 350 ha of direct disturbance. Potential death or injury of Malleefowl and destruction of mounds. Some indirect impacts to Malleefowl habitat health and behavioural impacts.	**Avoid**: N/A **Minimise**: • Implement industry best practice management measures for terrestrial fauna • Prepare and implement an Introduced Fauna Management Plan • Conduct pre-clearance surveys for active Malleefowl mounds and avoid wherever practicable	Habitat to be rehabilitated with stripped topsoil and seeded if required.	Can the environmental values be rehabilitated/Evidence? Disturbance is expected to be able to be rehabilitated such that it can be considered Malleefowl habitat Operator experience in undertaking rehabilitation? Audalia will utilise experienced operators to conduct the rehabilitation works What is the type of vegetation being rehabilitated? Woodland and shrubland Time lag? Expected to be several years before any rehabilitation areas become suitable Malleefowl habitat Credibility of the rehabilitation proposed (evidence of demonstrated success) There are very few rehabilitation sites in the area however mine site rehabilitation methods are well established	No					
Potential SREs - Clearing of up to 650 ha of potential SRE habitat and potential indirect impacts.	**Avoid**: N/A **Minimise**: • Implement industry best practice management measures for terrestrial fauna • Implement the Dust Management Plan	Habitat to be rehabilitated with stripped topsoil and seeded if required.	Can the environmental values be rehabilitated/Evidence? Disturbance is expected to be able to be rehabilitated such that it can be considered SRE habitat Operator experience in undertaking rehabilitation? Audalia will utilise experienced operators to conduct the rehabilitation works What is the type of vegetation being rehabilitated? Woodland and shrubland Time lag? Expected to be several years before any rehabilitation areas become suitable SRE habitat Credibility of the rehabilitation proposed (evidence of demonstrated success) There are very few rehabilitation sites in the area however mine site rehabilitation methods are well established	No					
Troglofauna species and populations that inhabit the Proposal mine pits - Excavation of troglofauna habitat within the proposed mine pits	**Avoid**: N/A **Minimise**: • Ensure the excavation of the proposed mine pits is the minimum	TSF and evaporation ponds will be closed and rehabilitated to prevent any significant ongoing impacts to troglofauna habitat	Can the environmental values be rehabilitated/Evidence? Mine pits are not proposed to be backfilled, however the removal of salts from the evaporation ponds and the gradual reduction in seepage	No					

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
Alteration of habitat characteristics due to mining and seepage from TSF and evaporation ponds	required to ensure safe and mining operations • Verify that troglofauna species and habitats are not restricted to the mine pits, TSF or Evaporation Ponds • Design, construct and operate the TSF and Evaporation Ponds in accordance with approvals required under the Mining Act and Part V of the EP Act		from the TSF will allow values to be reinstated in those areas Operator experience in undertaking rehabilitation? N/A What is the type of vegetation being rehabilitated? N/A Time lag? Several years after the cessation of operations Credibility of the rehabilitation proposed (evidence of demonstrated success) N/A						

11.3 Offset Principles

In WA, government decision making processes in relation to the use of environmental offsets are underpinned by six principles. These are set out in the Environmental Offsets Policy (Government of WA, 2011). The Proposal and proposed offset has been assessed against each of these principles, provided in Table 77.

Table 77: Assessment of the proposed offset against the six principles

No.	Principle	Assessment outcome
1	Environmental offsets will only be considered after avoidance and mitigation options have been pursued.	Audalia has applied the mitigation hierarchy by identifying measures to avoid, minimise and rehabilitate. Audalia's primary measure to meet this policy requirements was site selection and design, which avoided an minimised disturbance within several key flora habitat areas. The Development Envelope was reduced via a Section 43A accepted by the EPA on the 4 November 2020.
2	Environmental offsets are not appropriate for all projects.	It is acknowledged that offsets are not appropriate for all projects. As the Proposal may result in significant residual impacts on threatened and priority flora species, the proposed Bremer Range Nature Reserve and a PEC, an offset is considered to be required. The offsets proposed are considered to be appropriate to counterbalance the residual impacts on these environmental values.
3	Environmental offsets will be cost effective, as well as relevant and proportionate to the significance of the environmental value being impacted.	The proposed offsets have been designed to be cost-effective by targeting the retention and conservation of existing environmental values, and translocation of *E. rhomboidea* and *S. bremerense*. The offsets are cost-effective as Audalia will be active in the area during the duration of the offset implementation so logistical costs will be minimal. The required translocation studies and implementation is an extension of germination work already commissioned by Audalia (through DBCA) therefore Audalia has reasonable knowledge of the associated costs. The use of the proposed offsets for the Proposal is considered to be relevant and proportionate to the significance of the environmental value being impacted.
4	Environmental offsets will be based on sound environmental information and knowledge.	The proposed offsets have been designed to be cost-effective by targeting the retention and conservation of existing environmental values, and translocation of *E. rhomboidea* and *S. bremerense*. The values of the areas to be retained for conservation are well known given the level of ecological surveys and studies that Audalia have completed in the area. Although initial advice from Western Botanical (2018) indicates that germination is likely to be achievable, Audalia acknowledges that the proposed translocation of *E. rhomboidea* and *S. bremerense* is not yet based on sufficient environmental knowledge given that germination studies are still being completed. Nevertheless, the protection of these species within the proposed conservation area is expected to be the key offset mechanism for these species and suitable to counterbalance the residual impacts of the Proposal. The translocation offset is therefore supplementary and not essential to counterbalance the residual impacts of the Proposal on *E. rhomboidea* and *S. bremerense.*
5	Environmental offsets will be applied within a framework of adaptive management.	The combination of proposed offsets site will provide significant opportunities within the framework of adaptive management. The proposed offset site can potentially be used as a trial or pilot site for new approaches to threat reduction, and being under the management of DBCA or other management authority, will be consistently subject to new, more effective management techniques as these become best practice. The remaining offsets have been designed to be adaptive, utilising Audalia's improved experience in revegetation and germination during the first years of operation at the Proposal. This allows information and knowledge captured during operation to be used in an adaptive manner.
6	Environmental offsets will be focused on longer term strategic outcomes.	The proposed offsets have been designed to utilise improved information as it becomes available during the first years of operation at the Proposal. This allows information and knowledge captured during operation (regarding germination, translocation and revegetation) to be used to inform strategies to achieve solid strategic outcomes.

12 HOLISTIC IMPACT ASSESSMENT

The Proposal lies within the Great Western Woodlands; an area of known ecological significance, and intersects with the proposed Bremer Range Nature Reserve and Bremer Range Vegetation Complexes PEC. Several significant flora species were also identified within the Mine Study Area.

Given the above, Audalia incorporated extensive avoidance and minimisation measures into the Proposal design. The Proposal that was originally referred to the EPA under Section 38 of the EP Act included the direct disturbance of *M. aquilonaris*; a Threatened Flora taxon pursuant to the BC Act. Based on the mine plan that was originally proposed and referred to the EPA, a predicted 24% of known *M. aquilonaris* individuals would have been disturbed. Audalia has since commissioned numerous regional searches for this species and no other populations have been found, which has confirmed that the sub-populations at Medcalf are significant for the survival of this species. Given the restricted range and small population of *M. aquilonaris,* Audalia substantially altered their mine plan to avoid mining within or adjacent to the *M. aquilonaris* sub-populations, and minimising indirect impacts. Audalia also significantly reduced the extent of the Mine DE to exclude Priority Flora populations as much as practicable, and will ensure that the final design of the Proposal further reduces the potential impacts to Priority Flora (Table 36). This has carried significant economic implications, as the highest grade ore resource is located within and adjacent to the sub-populations.

There are some potential impacts that require management and monitoring to ensure that the impacts are not significant. Many of these potential impacts are adequately regulated under other legislation:

- TSF and evaporation pond seepage, brine spills and leaks, process plant dust and sewage will be regulated under Part V of the EP Act;
- Mine pit and TSF design, and general environmental management will be regulated through a MP assessed under the Mining Act; and
- Closure and rehabilitation will be regulated through a MCP assessed under the Mining Act.

There are some potential impacts however that are expected to require limits or conditions in the Ministerial Statement, including:

- Limits on total disturbance within each development envelope;
- Limits on the disturbance of *M. aquilonaris* sub-optimal habitat;
- Limits on the disturbance of *E. rhomboidea* and *S. bremerense* populations;
- A limit on groundwater abstraction volumes;
- The development and implementation of a Mine and Infrastructure Plan to demonstrate that the final locations of mine pits and infrastructure are sited such that the disturbance of significant flora and vegetation is minimised as far as practicable;
- The implementation of a Dust Control Management Strategy to ensure that dust impacts on flora and vegetation is minimised as far as practicable; and
- The implementation of a Significant Flora Monitoring Programme to ensure that indirect impacts on flora and vegetation are strictly monitored and to allow contingency actions to be taken.

Based on the above, and the assessment provided in Sections 6 – 9, the Proposal is expected to be able to meet the EPA's objectives for Terrestrial Fauna, Subterranean Fauna, Terrestrial Environmental Quality and Inland Waters.

Residual impacts to three significant flora species (*M. aquilonaris*, *E. rhomboidea* and *S. bremerense*), the proposed Bremer Range Nature Reserve and the Bremer Range Vegetation Complexes PEC are considered to remain significant once mitigation measures are implemented. Offset measures are deemed to be required to counterbalance these residual impacts to ensure that the EPA objective for Flora and Vegetation can be met. Audalia has completed a WA Offsets Template as per the requirements of the WA Environmental Offsets Guideline (EPA, 2014), provided in Section 11. These offset measures will be reviewed and refined during the assessment process through discussions with DBCA, DMIRS and EPA Services to ensure they adequately counterbalance the residual impacts. Audalia has developed a draft Offsets Strategy (Appendix 12) which will be refined in consultation with DBCA and DMIRS during the assessment process. The draft Offsets Strategy provides the scale of the offsets discussed in Section 11 and will need to be reviewed and accepted by EPA Services prior to Proposal implementation (expected to be a Ministerial Condition).

Audalia considers that the residual impacts to *M. aquilonaris*, *E. rhomboidea*, *S. bremerense*, the proposed Bremer Range Nature Reserve and the Bremer Range Vegetation Complexes PEC are able to be counterbalanced by the implementation of the offsets detailed in Section 11 and the draft Offsets Strategy, such that the EPA's objective for Flora and Vegetation is able to be met.

13 GLOSSARY

Term	Meaning
AHD	Australian Height Datum
ANOSIM	Analysis of Similarities
ANZECC	Australian and New Zealand Environment and Conservation Council
Audalia	Audalia Resources Limited
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulphate Soils
BAM Act	*Biosecurity and Agriculture Management Act 2007* (WA)
BC Act	*Biodiversity Conservation Act 2016* (WA)
BIF	Banded Ironstone Formations
BoM	Bureau of Meteorlogy
Botanica	Botanica Consulting
BSP	Base Saturation Percentage
CEC	Cation exchange capacity
CFD	Computational Fluid Dynamics
Cube	Cube Consulting Pty Ltd
D	Monthly Dust Deposition
DBCA	Department of Biodiversity Conservation and Attractions
DAWE	Department of Agriculture, Water and the Environment
DE	Development Envelope
DEC	Department of Environmental Conservation
DER	Department of Environment Regulation
DEWHA	Department of the Environment, Water, Heritage and the Arts
DMIRS	Department of Mines, Industry Regulation and Safety
DMP	Department of Mines and Petroleum
DotEE	Department of the Environment and Energy (Commonwealth)
DoW	Department of Water
DPaW	Department of Parks and Wildlife
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority (WA)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ERD	Environmental Review Document
ESD	Environmental Scoping Document

Term	Meaning
ESP	Exchangeable Sodium Percentage
GCA	Graeme Campbell and Associates
GDE	Groundwater Dependent Ecosystem
GHG	Greenhouse Gas
GIL	Groundwater Investigation Level
Golder	Golder Associates Pty Ltd
GL	Gigalitre
GRM	Groundwater Resource Management
HPDW	high-purity-deionised-water
HU	Hydrogeological Unit
IBRA	Interim Biogeographic Regionalisation for Australia
LoM	Life of Mine
M. aquilonaris	*Marianthus aquilonaris*
MCP	Mine Closure Plan
Mining Act	*Mining Act 1978*
MP	Mining Proposal
MRWA	Main Roads WA
Mt	Million tonnes
NAF	Non-acid Forming
nMDS	Non-metric multi-dimensional scaling
NPI	National Pollutant Inventory
NVIS	National Vegetation Information System
P	Estimated Reductions in Primary Dry Matter Production
PEC	Priority Ecological Communities – plant communities listed as being potentially threatened under the *Biodiversity Conservation Act 2016*
PFS	Pre-feasibility Study
PoW	Programme of Works
Proposal	Medcalf Project
PVA	Production Viability Analysis
RIWI Act	*Rights in Water and Irrigation Act 1914*
RO Plant	Reverse Osmosis Plant
Ramboll	Ramboll Australia Pty Ltd
RL	Relative Level
ROM	Run of mine
SRE	Short-range Endemic
TDS	Total Dissolved Solids
TEC	Threatened Ecological Communities – plant communities listed as being threatened and legally protected under the *Biodiversity Conservation Act 2016* and / or the *Environment Protection and Biodiversity Conservation Act 1999*
TSF	Tailings Storage Facility
TSSC	Threatened Species Scientific Committee
UCL	Unallocated Crown Land

Term	Meaning
WA	Western Australia
WRL	Waste rock landform

14 REFERENCES

ANCOLD (2019). *Guidelines on Tailings Dams: Planning, Design, Construction, Operation and Closure – Revision 1.* Retrieved from: https://www.ancold.org.au/?product=guidelines-on-tailings-dams-planning-design-construction-operation-and-closure-may-2012

Anon. (1992). *South Coast Region Regional Management Plan 1992–2002. Management Plan 24.* (Department of Conservation and Land Management: Perth)

ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Canberra, ACT. Audalia Resources Limited (2019). Medcalf Project Environmental Scoping Document. Prepared for Audalia Resources Limited by Preston Consulting Pty Ltd. 26 March 2019.

Armstrong (2012). *Vegetation Survey and Rare Flora search on the Vesuvius Prospect Medcalf Project.* Unpublished report prepared for Audalia Resources Limited. Paul Armstrong and Associates.

AusGrass2. (2010). *Pentameris airoides. Grasses of Australia*. Retrieved from http://ausgrass2.myspecies.info/content/pentameris-airoides

Australian Government (2012). Atlas of Groundwater Dependent Ecosystems (GDE Atlas), Phase 2. Australian Government National Water Commission. July 2010.

Australian Soil Resource Information System (2014). Atlas of Australian Soils Database, Australian Soil Resource Information System. Retrieved from: https://www.asris.csiro.au/themes/AcidSulfateSoils.html

Baehr, M., and Main, D. (2016). New genera and species of subterranean Anilline Bembidiini from the Pilbara, northwestern Australia (Insecta: Coleoptera: Carabidae: Bembidiini: Anillina). Records of the Western Australian Museum 31, 59-89.

Barker, R. M (1990). New Species New Combinations and Other Name Changes in Hakea (proteaceae). Adelaide Journal of Botany. 13: 95 110.

Barnett et al. (2012). *Australian Groundwater Modelling Guidelines. Waterlines Report.* National Water Commission. Canberra, ACT.

Barrett, G., A. Silcocks, S. Barry, R. Cunningham & R. Poulter (2003). The New Atlas of Australian Birds. Melbourne, Victoria: Birds Australia.

Beard, J.S., (1990). Plant Life of Western Australia, Kangaroo Press Pty Ltd, NSW.

Bell, J.G., Kilgour, P.L., English, P.M., Woodgate, M.F., Lewis, S.J., and Wischusen, J.D.H. (2012). WASANT Palaeovalley Map - Distribution of Palaeovalleys in Arid and Semi-arid WA-SA-NT (First Edition), scale: 1:4 500 000. In '.' (Geoscience Australia: Canberra).

Brook, B.W., O'Grady, J.J., Chapman, A.P., Burgman, M.A., Akçakaya, H.R. & Frankham, R. (2000) Predictive accuracy of population viability analysis in conservation biology. Nature, 404, 385–387.

Bennelongia Environmental Consultants (2009). Yilgarn Iron Ore Project: Carina deposit, subterranean fauna assessment. Report 2009/69, Bennelongia Pty Ltd, Jolimont, WA, 30 pp.

Bennelongia Environmental Consultants (2011). Duketon Gold Project: Subterranean Fauna Assessment at Garden Well and Erlistoun. Report 2011/110, Bennelongia Pty Ltd, Jolimont, WA.

Bennelongia Environmental Consultants (2013). Mt Henry gold project: troglofauna desktop assessment and pilot survey. Report 2013/197, Bennelongia Pty Ltd, Jolimont, WA, 22 pp.

Bennelongia Environmental Consultants (2016a). J5 and Bungalbin East Project: Additional Troglofauna Investigation. Report 2016/287, Bennelongia Pty Ltd, Jolimont, WA, 33 pp.

Bennelongia Environmental Consultants (2016b). Mining Area C – Southern Flank: Troglofauna Assessment. Report 2016/275, Bennelongia Pty Ltd, Jolimont, WA, 46 pp.

Bennelongia Environmental Consultants (2020). Medcalf Project: Assessment of Subterranean Fauna Values. Prepared for Audalia Resources Limited. June 2020.

Bennelongia Environmental Consultants (2020). Medcalf Project: Assessment of Subterranean Fauna Values. Prepared for Audalia Resources Limited. November 2020

Bennelongia Environmental Consultants (2020). Short-range endemic fauna at the Medcalf Project. Prepared for Audalia Resources Limited. November 2020.

Benshemesh, J. (2007). National Recovery Plan for Malleefowl. Department for Environment and Heritage, South Australia.

Biota Environmental Sciences (2006a). Forrestania Fauna Survey – Fauna and Fauna Assemblages Report. Unpublished report for Western Areas NL.

Biota Environmental Sciences (2006b). Forrestania Water Disposal Pipeline Survey – Fauna and Faunal Assemplages Report. Unpublished report for Western Areas NL.

Biota Environmental Sciences (2007a). Forrestania Monitoring Survey, Flying Fox Phases III and IV. Unpublished report for Western Areas NL.

Biota Environmental Sciences (2007b). Diggers South Fauna Survey – Phase I. Unpublished report for Western Areas NL.

Biota Environmental Sciences (2010). Spotted Quoll Haul Road Single Phase Fauna Survey. Unpublished report for Western Areas N.L. May 2010.

Booth, T. H., Williams, K. J., & Belbin, L. (2012). *Developing biodiverse plantings suitable for changing climatic conditions 2: Using the Atlas of Living Australia*. Ecological Management & Restoration 13(3), 274-281. doi: https://doi.org/10.1111/emr.12000

Botanica Consulting (2013). *Flora of Conservation Significance search of the Medcalf Exploration Project.* May 2013, Botanica Consulting, June 2013.

Botanica Consulting (2015). *Level 2 Flora & Vegetation Survey for the Medcalf Vanadium Mining Project Spring 2013 to Autumn 2015.* Botanica Consulting, June 2015.

Botanica consulting (2017a). Detailed Flora & Vegetation Survey. Medcalf Vanadium Mining Project and Proposed Haul Road. Prepared for Audalia Resources Limited. October 2017. Version 2.

Botanica (2017b). Memorandum: *Marianthus aquilonaris*. Memorandum prepared for Audalia Resources Limited by Botanica Consulting, November 2017.

Botanica Consulting (2019). *Marianthus aquilonaris* Landform Monitoring: Spring 2018.

Botanica Consulting (2020a). *Marianthus aquilonaris* Demographic Monitoring: Spring 2018-Spring 2019.

Botanica Consulting (2020b). Seed quality of Eucalyptus rhomboidea, Hakea pendens and *Marianthus aquilonaris* seed collections collected by Botanica Consulting for Audalia Resources Limited.

Botanica Consulting (2020c). Detailed Flora & Vegetation Survey Medcalf Vanadium Mining Project & Proposed Haul Road. Prepared for Audalia Resources Limited. February 2020.

Botanica Consulting (2020d). Flora and Vegetation Impact Assessment Medcalf Project. Prepared for Audalia Resources Limited. June 2020.

Botanica Consulting (2020e). Updated Summary on ecology of *Marianthus aquilonaris*. Prepared for Audalia Resources Limited. March 2020.

Botanica Consulting (2020f). Critical Habitat Assessment-Eucalyptus rhomboidea and Stenanthemum bremerense Prepared For Audalia Resources Limited. November 2020

Brearley, D.R, Dunlop, N.J and Osborne, J.M, (1998). *Biological Survey and Environmental Assessment of the Emily Ann Project Area.* School of Environmental Biology Curtin University of Technology.

Bush, B.; Maryan, B.; Browne-Cooper, R. and Robinson, D. (2007). Reptiles and Frogs in the Bush: Southwestern Australia. UWA Press, Nedlands.

Butler, B. (2020). Brief description of Medcalf geology memo. Prepared for Audalia Medcalf Project. 17 March 2020.

Butler, B. (2020b) Technical Memorandum: Response to EPA Comments on Waste Rock Sampling. Unpublished memorandum prepared for Audalia Medcalf Project.

CALM (1994). A Representative Marine Reserve System for Western Australia, Report of the Marine Parks and Reserves Selection Working Group, Department of Conservation and Land Management, Perth, Australia.

Car, C.A., Beavis, A.A., Burger, M.A., and Castalanelli, M.A. (2012). Arachnids and myriapods from Mummaloo, NE of Wubin, and Lake Giles, NW of Kalgoorlie, Western Australia - Brief report to Bennelongia. Western Australian Museum (WAMTS063).

Churchill, S. (2008). Australian Bats. Second Edition, Allen & Unwin.

Cogger, H. G. (2014). Reptiles and Amphibians of Australia. 7th Edition. CSIRO Publishing.

Collins, J., & Lullfitz, B. (2009). Central Wheatbelt District Threatened Flora and Communities Management Program. Annual Report. Department of Environment and Conservation, WA.

Commander D.P. and McGowan R.J. (1992). Hydrogeology of the Tertiary Paleochannels in the Kalgoorlie region (Roe Palaeodrainage) Western Australian Geological Survey.

Commonwealth of Australia (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian Government Initiative, Australian Capital Territory. Accessed: https://www.waterquality.gov.au/guidelines/anz-fresh-marine

Cowan, M. (2001). A Biodiversity Audit of Western Australia's 53 Biogeographical Region in 2001- Eastern Goldfield (COO3) subregion, Department of Conservation and Land Management.

Craig, G. F., & Coates, D. J. (2001). Declared Rare and Poorly Known Flora in the Esperance District. Wildlife Management Program No 21. Department of Conservation and Land Management, WA.

Cresswell, J. E., & Osborne, J. L. (2004). The effect of patch size and separation on bumblebee foraging in oilseed rape: implications for gene flow. Journal of Applied Ecology, 41(3), 539-546.

Cube Consulting (2019). Medcalf Mining Project. Mining Engineering Scoping Study. Technical Report. Prepared for Audalia Resources Limited. September 2019.

DBCA (2019), Component 2 Report Assessment of genetic diversity in sub-populations of Marianthus aquilonaris. Prepared by Dr Tara Hopley and Dr Margaret Byrne Biodiversity and Conservation Science, Department of Biodiversity, Conservation and Attractions, for Audalia Resources Limited.

Department of Biodiversity, Conservation and Attractions (2017). Priority Ecological Communities for Western Australia. Version 27. 30 June 2017.

Department of Biodiversity, Conservation and Attractions (2018a). 2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Simplified Report). Department of Biodiversity, Conservation and Attractions.

Department of Biodiversity Conservation and Attractions. (2018b). Ministerial Guideline No. 2 – Threatened and Extinct Species Listing Procedures and Criteria Biodiversity Conservation Act 2016. Retrieved from: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/118-call-for-public-nominations-for-listing-and-delisting-of-threatened-plants-and-animals

Department of Biodiversity Conservation and Attractions. (2018c). Threatened Plants, Threatened and priority flora list. Retrieved from: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-plants

Department of Biodiversity Conservation and Attractions (2019a). Assessment of genetic diversity in sub-populations of *Marianthus aquilonaris*. Biodiversity and Conservation Science, Department of Biodiversity, Conservation and Attractions. December 2019

Department of Biodiversity Conservation and Attractions (2019b). EPA Redbook Recommended Conservation Reserves 1976-1991 (DBCA-029). October 2010. Retrieved from: https://catalogue.data.wa.gov.au/dataset/epa-redbook-recommended-conservation-reserves-1976-1991

Department of Biodiversity Conservation and Attractions. (2019c). Priority Ecological Communities for Western Australia Version 28. Species and Communities Program. 17 January 2019. Retrieved from https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities

Department of Environment and Conservation (2007), Recommended Interim Protocol for Flora Surveys of Banded Ironstone Formations (BIF) of the Yilgarn Craton, Department of Environment and Conservation, Western Australia.

Department of Environment and Conservation (2009), Fauna Notes Information about Western Australia's fauna – No. 24 Western rosella. (Available at: https://library.dbca.wa.gov.au/static/fulltextfiles/922919.pdf)

Department of Environment and Conservation (2010a). A Biodiversity and Cultural Conservation Strategy for the Great Western Woodlands. Retrieved from: https://www.dpaw.wa.gov.au/management/off-reserve-conservation/the-great-western-woodlands

Department of Environment and Conservation. (2010b). Bremer *Marianthus* (*Marianthus aquilonaris*) Interim Recovery Plan 2010-2014. Retrieved from https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/recovery_plans/approved_interim_recovery_plans_/marianthus_aquilonaris.pdf

Department of Environment and Conservation (2010c). *Interim recovery plan No. 303 Bremer Marianthus (Marianthus aquilonaris) Interim Recovery Plan 2010-2014.* Department of Environment and Conservation.

Department of Environment and Conservation (2011). A biodiversity and cultural conservation strategy for the Great Western Woodlands. Department of Environment and Conservation.

Department of Environment and Conservation (2012). Chuditch (*Dasyurus geoffroii*) National Recovery Plan. Wildlife Management Program No. 54. Department of Environment and Conservation. 2012.

Department of Environment and Conservation. (2013). Threatened Species Communities Recovery Team Annual Report. Retrieved from https://library.dbca.wa.gov.au/static/fulltextfiles/072077.pdf

Department of Environment Regulation (2014). Assessment and management of contaminated sites Contaminated sites guidelines. December 2014.

Department of Environment Regulation (2015). Identification and investigation of acid sulfate soils and acidic landscapes. June 2015.

Department of the Environment (2008). Threat Abatement Plan for the Predation by the European Red Fox. Government of Australia, Australian Capital Territory. Retrieved from: https://www.environment.gov.au/system/files/resources/1846b741-4f68-4bda-a663-94418438d4e6/files/tap-fox-report.pdf

Department of the Environment (2015). Threat Abatement Plan for the Predation by Feral Cats. Government of Australia, Australian Capital Territory. Retrieved from: https://www.environment.gov.au/system/files/resources/78f3dea5-c278-4273-8923-fa0de27aacfb/files/tap-predation-feral-cats-2015.pdf

Department of the Environment (2016). Threat Abatement Plan for competition and land degradation by rabbits. Australian Capital Territory. Retrieved from: https://www.environment.gov.au/system/files/resources/bf9352c2-35ae-4a80-8828-96de630731a9/files/tap-rabbit-2016.pdf

Department of the Environment and Energy (2012). Interim Biogeographic Regionalisation of Australia, Version 7. Retrieved from:

https://www.environment.gov.au/system/files/pages/5b3d2d31-2355-4b60-820c-e370572b2520/files/bioregions-new.pdf

Department of the Environment and Energy (2016). Threat abatement plan for competition and land degradation by rabbits. Retrieved from: https://www.environment.gov.au/system/files/resources/bf9352c2-35ae-4a80-8828-96de630731a9/files/tap-rabbit-2016.pdf

Department of the Environment and Energy (2017a). *Protected Matters Search Tool, Environment Protection and Biodiversity Conservation Act 1999*, Department of the Environment and Energy.

Department of the Environment and Energy (2017b). *National Vegetation Information System. Major Vegetation Groups, Version 4.2*, Department of the Environment and Energy.

Department of the Environment, Water, Heritage and the Arts (2008). *Background Document for the Threat Abatement Plan for predation by the European red fox*.

Department of the Environment, Water, Heritage and the Arts (2010). *Survey Guidelines for Australia's Threatened Birds*.

Department of the Environment, Water, Heritage and the Arts (2011). *Survey Guidelines for Australia's Threatened Mammals*.

Department of Mines and Petroleum (2013a). *Tailings storage facilities in Western Australia – code of practice: Resources Safety and Environment Divisions*, Department of Mines and Petroleum, Perth, Western Australia.

Department of Mines and Petroleum (2013b). Statewide spatial datasets: mineral information. Department of Mines and Petroleum, Perth. Retrieved from: http://dmp.wa.gov.au/Data-and-Software-Centre-1483.aspx.

Department of Mines and Petroleum (2015a). Guidelines for Preparing Mine Closure Plans. Government of Western Australia, Perth, Western Australia.

Department of Mines and Petroleum (2015b). Guide to the preparation of a design report for tailings storage facilities. Government of Western Australia. August 2015.

Department of Mines, Industry Regulation and Safety (2020a). Statutory Guidelines for Mine Closure Plans.

Department of Mines, Industry Regulation and Safety (2020b). Mine Closure Plan Guidance – How to prepare in accordance with Part 1 of the 'Statutory guidelines for Mine Closure Plans'.

Department of Parks and Wildlife (2017). *Threatened and Priority Flora Database search results*, Department of Parks and Wildlife.

Department of Primary Industries and Regional Development (2017). Declared Organism-database search, Department of Primary Industries and Regional Development, Western Australia. Retrieved from: http://www.biosecurity.wa.gov.au/ Accessed: 20/10/2017

Department of Water (2013). *Western Australia Water in Mining Guideline. Water licensing delivery report series. Report No. 12.* Department of Water, Perth, Western Australia, 2013.

DHI (2018). Mike SHE. https://www.mikepoweredbydhi.com/products/mike-she. Danish Hydraulics Institute, Denmark.

Doley, D. & Rossato, L. 2010 'Mineral Particulates and Vegetation: Modelled effects of Dust on Photosynthesis in Plant Canopies', Air Quality and Climate Change, Volume 44 No.2, May 2010.

DPIRD (2014), Soil Landscape System of Western Australia, Department of Primary Industries and Regional Development.

Duncan, A.; Baker, G. B.; Montgomery, N.; and Natural Heritage Trust (Australia) (1999). The action plan for Australian bats / edited by Anne Duncan, G. Barry Baker and Narelle Montgomery; with assistance from Lindy Lumsden *et al.* Natural Heritage Trust, Canberra.

Duncan, S., Traill, B. J., & Watson, C. (2006). Vertebrate Fauna of the Honman Ridge-Bremer Range District, Great Western Woodlands, Western Australia. The Wilderness Society. Perth, WA.

Eberhard, S.M., Halse, S.A., and Humphreys, W.F. (2005) Stygofauna in the Pilbara, north-west Western Australia: a review. Journal of the Royal Society of Western Australia 88, 167-176.

Ecoscape. (2017). State Barrier Fence Biological Surveys. Department of Agriculture and Food Western Australia. 9309-3087-13R FINAL REV2.

Environmental Protection Authority (2006). *Guidance Statement No. 6 – Rehabilitation of Terrestrial Ecosystems.* Environmental Protection Authority, Perth, Western Australia, 2006.

Environmental Protection Authority (2011). *WA Environmental Offsets Policy*. September 2011.

Environmental Protection Authority (2013). *Environmental Protection Bulletin 20 - Protection of naturally vegetated areas through planning and development.* Environmental Protection Authority, Perth, Western Australia, 2013.

Environmental Protection Authority (2014). *WA Environmental Offsets Guidelines*. August 2014.

Environmental Protection Authority (2016a). *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016.* 13 December 2016.

Environmental Protection Authority (2016b). *Instructions on how to define the key characteristics of a proposal.*

Environmental Protection Authority (2016c). *Environmental Factor Guideline. Flora and Vegetation*. December 2016.

Environmental Protection Authority (2016d). *Technical Guidance. Flora and Vegetation Surveys for Environmental Impact Assessment.* Environmental Protection Authority. December 2016.

Environmental Protection Authority (2016e). Environmental Protection Authority. *Environmental Factor Guideline. Terrestrial Fauna.* December 2016.

Environmental Protection Authority (2016f). *Technical Guidance. Sampling Methods for Terrestrial Vertebrate Fauna.* Environmental Protection Authority. December 2016.

Environmental Protection Authority (2016g). *Technical Guidance. Terrestrial Fauna Surveys.* Environmental Protection Authority. December 2016.

Environmental Protection Authority (2016h). *Technical Guidance. Sampling of Short Range Endemic Invertebrate Fauna.* Environmental Protection Authority. December 2016.

Environmental Protection Authority (2016i). Environmental Protection Authority. *Environmental Factor Guideline. Subterranean Fauna*. December 2016.

Environmental Protection Authority (2016j). *Technical Guidance. Subterranean Fauna Survey.* December 2016.

Environmental Protection Authority (2016k). *Technical Guidance. Sampling Methods for Subterranean Fauna.* December 2016.

Environmental Protection Authority (2016l), *Environmental Factor Guideline, Terrestrial Environmental Quality*, December 2016.

Environmental Protection Authority (2018a). *Environmental Factor Guideline, Inland Waters Environmental Quality.* June 2018.

Environmental Protection Authority (2020a). *Statement of Environmental Principles, Factors and Objectives.* April 2020.

Environmental Protection Authority (2020b). *Instructions on how to prepare an Environmental Review Document.* March 2020.

Environmental Protection Authority (2020c). *Environmental Impact Assessment (EIA) (Part IV Divisions 1 and 2) Procedures Manual.* Environmental Protection Authority, Perth, Western Australia, 2020.

Environmental Protection Authority (2020d). *Instructions on how to Prepare Environmental Protection Act 1986 Part IV Environmental Management Plans.* March 2020.

Environmental Protection Authority (2020e), *Environmental Factor Guideline, Air Quality*, April 2020.

Environmental Protection Authority (2020f), *Environmental Factor Guideline, Greenhouse Gas Emissions*, April 2020.

Euclid. (2019). Eucalyptus pterocarpa. Retrieved from http://keyserver.lucidcentral.org:8080/euclid/data/02050e02-0108-490e-8900-0e0601070d00/media/html/eucalyptus_pterocarpa.htm#description

Farmer, A. (1991). The effects of dust on vegetation—a review. Retrieved from: https://www.sciencedirect.com/science/article/abs/pii/026974919390179R?via%3Dihub

Fet, V. & Lowe, G. (2000). Family Buthidae C.L. Koch, 1837. In: Fet, V., Sissom, W. D., Lowe, G. & Braunwalder, M. E. (eds) Catalogue of the scorpions of the world (1758-1998). New York Entomological Society, New York, pp. 54–286.

Figgis, B.; Guo, B.; Javed, W.; Ahzi, S.; and Remond, Y. (2018). Dominant environmental parameters for dust deposition and resuspension in desert climates. Retrieved from: https://www.tandfonline.com/doi/full/10.1080/02786826.2018.1462473

Geoscience Australia (2017). Groundwater Dependent Ecosystems. Australian Government http://www.ga.gov.au/scientific-topics/water/groundwater/understanding-groundwater-resources/groundwater-dependant-ecosystems Accessed: 23/06/2017

GA (2018). Surface Geology of Australia (1:1M scale dataset). https://data.gov.au/dataset/c45023db-d207-4806-9f50-b38fcff0b5df. Australian Government: Geoscience Australia.

Gibson, N., & Lyon, M. N. (1998a). Flora and Vegetation of the Eastern Goldfields Ranges: Part 3. Parker Range. Journal of the Royal Society of Western Australia, 81: 119-129.

Gibson, N. & Lyons, M.N (1998b), Flora and Vegetation of the Eastern Goldfields Ranges: Part 2. Bremer Range, Journal of the Royal Society of Western Australia, 81:107-117.

Golder Associates (2020). Medcalf Project. *Tailings Storage Facility Design Concept.* Prepared for Audalia Resources Limited. Golder Associates Pty Ltd. Perth, Western Australia.

Government of Western Australia (2002). Environmental Protection (Rural Landfill) Regulations 2002. As at 01 Jul 2002 Version 00-a0-13. Published on www.legislation.wa.gov.au

Government of Western Australia (2004). *State Water Quality Management Strategy Document No. 6.* Perth, Western Australia.

Graeme Campbell and Associates (2020a). Medcalf Project: Geochemical Characterisation of Slurry Samples of Deslimed-Tailings and Gravity-Reject-Tailings and Implications for Tailings Management.

Graeme Campbell and Associates (2020b). Medcalf Project: Characterisation of Mine-Waste Samples from Vesuvius, Fuji, Egmont, and Pinatubo Pits – Implications for Mine-Waste Management.

Groundwater Resource Management (2015). Medcalf Project Water Supply Desk Study. Prepared for Audalia Resources Limited. September, 2015.

Groundwater Resource Management (2020a). Lake Medcalf Hydrogeological Study: *Surface Water Assessment*. Prepared for Audalia Resources Limited. October, 2019.

Groundwater Resource Management (2020b). Groundwater Supply Investigation. Audalia Resources Limited. Medcalf Vanadium Project. March, 2020.

Groundwater Resource Management (2020c). Lake Medcalf Hydrogeological and Hydrological Study: *Characterisation of Marianthus Aquilonaris* Habitat. Prepared for Audalia Resources Limited. June 2020.

Groundwater Resource Management (2020d). Medcalf vanadium project – haul road water supply. May 2020.

Geoscience Australia (2009), Spatial Database on Atlas of Australian Soils. Created by National Resource Information Centre.

Gower, C.F., and Bunting, J.A. (1971). Lake Johnston. Sheet SI 51-1. In 'Australian 1:250 000 Geological Series.' (Geological Survey of Western Australia: Perth)

Halse, S.A., Scanlon, M.D., Cocking, J.S., Barron, H.J., Richardson, J.B., and Eberhard, S.M. (2014) Pilbara stygofauna: deep groundwater of an arid landscape contains globally significant radiation of biodiversity. Records of the Western Australian Museum Supplement 78, 443-483.

Harewood, G. (2020a). *Medcalf Vanadium Mining Project Fauna Survey (Level 2) - Phase 1 and Phase 2*. Prepared for Audalia Resources Limited. February 2020, Version 3.

Harewood, G. (2020b). *Medcalf Vanadium Mining Project Proposed Haul Road Fauna Assessment*. Prepared for Audalia Resources Limited. February 2020, Version 3.

Harvey, F. S. B., Framenau, V. W., Wojcieszek, J. M., Rix, M. G. and Harvey, M. S. (2012). Molecular and morphological characterisation of new species in the trapdoor spider genus Aname (Araneae: Mygalomorphae: Nemesiidae) from the Pilbara bioregion of Western Australia. Zootaxa 3383: 15–38.

Henry-Hall, N.J., Hopper, S.D., McKenzie, N.L. & Keighery, G.J. (1990). *Nature Conservation Reserves in the Eastern Goldfields, Western Australia*. Report to the EPA Red Book Task Force, pp. 264

Hislop, M. & Cranfield, R. J. (2014). *Brachyloma stenolobum (Ericaceae: Styphelioideae: Styphelieae), a new, white-flowered species for Western Australia.* Journal of the Western Australian Herbarium, Nuytsia, 24: 255-261.

Hopper, S.D. & Nicolle, D. (2007). *Diamond gum (Eucalyptus rhomboidea: Myrtaceae) a new threatened species endemic to the Bremer Range of the Southwest Australian Floristic Region*. Nuytsia 17: 185-194.

Horsnell, T. K. (2008). Quantifying thresholds for native vegetation to salinity and waterlogging for the design of direct conservation approaches. Thesis presented for the degree of Master of Engineering Science, UWA.

Hose, G.C., Sreekanth, J., Barron, O., and Pollino, C. (2015) Stygofauna in Australian Groundwater Systems: Extent of knowledge. CSIRO, Australia, 71 pp.

Houston, T. F. (1969). Observations on the nests and behaviour of some euryglossine bees (Hymenoptera: Colletidae). Australian Journal of Entomology, 8(1), 1-10.

How et al, (1988). The Biological Survey of the Eastern Goldfields of Western Australia: Part 4 lake Johnston-Hyden study area.

International Network for Acid Prevention (2014). Global Acid Rock Drainage Guide. Retrieved from: https://www.inap.com.au/

Javanmard, Z.; Tabari, M. K.; Bahrami, H.; Hosseini, S. M.; Modarres, S. A.; and Struve, D (2019). *Dust collection potential and air pollution tolerance indices in some young plant species in arid regions of Iran*. iForest - Biogeosciences and Forestry, Volume 12, Issue 6, Pages 558-564 (2019). Retrieved from: https://iforest.sisef.org/contents/?id=ifor3063-012

Javidkar, S.M., King, R.A., Cooper, S.J.B., Humphreys, W.F., and Austin, A.D. (2017). Taxonomy of Paraplatyarthrus Javidkar and King (Isopoda: Oniscidea: Paraplatyarthridae) with description of five new species from Western Australia, and comments on Australian Trichorhina Budde-Lunde, 1908 (Platyarthridae). 2017 4243, 31.

Johnstone, R. E. and Storr, G. M. (1998). Handbook of Western Australian Birds: Volume 1 – Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth Western Australia.

Just Design Engineering (2019). Medcalf Project GHG Estimation.

Keighery, B.J. (1994). Bushland plant survey. A guide to plant community survey for the community. Wildflower Society of WA (Inc.), Nedlands, Western Australia.

Kern A.M. (1995). Hydrogeology of the Widgiemooltha 1:250 000 sheet. Geological Survey of Western Australia.

King, J. 1986. The systematics of some Australian Megachilidae (Hymenoptera: Apoidea). Unpubl. PhD Thesis. Brisbane: Univ. of Queensland.

Knight Piesold Pty Ltd (2019). Medcalf project – geotechnical desktop study of pit north shell stability. July 2019.

Landgate (2019). Landgate fire watch database. Landgate Western Australian Government http://firewatch.landgate.wa.gov.au/landgate_firewatch_public.asp

Lucid. (2019). Teucrium sp. dwarf entity. Lucidcentral.org.

Magee, J.W. (2009). Palaeovalley Groundwater Resources in Arid and Semi - Arid Australia – A Literature Review. Geoscience Australia Record 2009/03. 224 pp.

Main, B. Y. and Framenau, V. W. (2009). A new genus of mygalomorph spider from the Great Victoria Desert and neighbouring arid country in south-eastern Western Australia (Araneae: Nemesiidae). Records of the Western Australian Museum 25: 177–285.

Main Roads Western Australia (2020). Statewide Traffic Digest 2014/15 – 2019/20. https://reportingcentreresources.mainroads.wa.gov.au/public/data/xrc4111/AADT/traffic_digest.pdf

Marnham, J.R., and Morris, P.A. (2003) Regolith geology of Western Australia (1:500 000 scale; preliminary edition): Geological Survey of Western Australia.

Maslin, B. R. (1999). Acacia miscellany 16. The taxonomy of fifty-five species of Acacia, primarily Western Australian, in section Phyllodineae (Leguminosae: Mimosoideae). Nuytsia 12(3): 311-411.

Matsuki, M., Gardener, M., Smith, A., Howard, K. & Gove, A. 2016. 'Impacts of dust on plant health, survivorship and plant communities in semi-arid environments', Austral Ecology, Volume 41, pp 417-427.

Mattiske Consulting Pty Ltd. (2019). Earl Grey Lithium Project Conservation Significant Flora Targeted Survey. Prepared for Covalent Lithium Pty Ltd. Doc ref: KID180 3 /0 33 /1 8.

Mc Donald, R.C, Isbell, R.F & Speight, J.G (1998). Australian Soil and Land Survey Field Handbook (3rd edn). CSIRO Publishing: Melbourne.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J., and Hopkins, M.S. (1990) Australian Soil and Land Survey - Field Handbook. 2nd ed., Inkata Press, Melbourne, Australia.

McKenzie, N.L., May J.E. and McKenna, S, (2002) Bioregional Summary of the 2002 Biodiversity Audit for Western Australia.

Michener, C. D. (2007). The Bees of the World. 2nd Edn. (2 ed.). Baltimore: Johns Hopkins.

Miller, P.S. and Lacy, R.C. (2005) VORTEX: A Stochastic Simulation of the Extinction Process. Version 9.50. User's Manual. Conservation Breeding Specialist Group (SSC/IUCN), Apple Valley, Minnesota.

Morcombe, M. (2004). Field Guide to Australian Birds. Steve Parish Publishing, Archerfiled, Queensland.

Morcombe, M., & Stewart, D. (2011). The Michael Morcombe eGuide to Australian Birds. Steve Parish Publishing. Brisbane, QLD.

National Pollutant Inventory (NPI). 2012. 'Emission Estimation Technique Manual for Mining.' Version 3.1, January 2012.

Navarro, T., Oualidi, J., & Trigo, M. M (2004). Pollen Morphology of Teucrium (Labiatae) and its taxonomic value. Belgian Journal of Botany. 137(1), 70-84.

Nichols, O.G. & F.M. Nichols (1984). The reptilian, avian and mammalian fauna of the Mount Saddleback State Forest, Western Australia. Western Australian Naturalist. 15:179-189.

NSW Environment and Heritage (2012). Erosion and Sediment Control on Unsealed Roads - A field guide for erosion and sediment control maintenance practices. ISBN 978-1-74293-647-5 ID OEH20120410. 1 June 2012.

Prendergast, K. (2019). Insect visitors to Marianthus aquilonaris and surrounding flora Nov 2-4, 2019. Prepared for Audalia Resources Limited.

Prendergast, K., Menz, M., Dixon, K. & Bateman, B. (2020). The relative performance of sampling methods for native bees: an empirical test and review of the literature. Ecosphere, accepted.

Prober, S.; K. Thiele; P. Runder; C. Yates; S. Berry; M. Byrne; L. Christidis; C. Gosper; P. Grierson; K. Lemson; T. Lyons; C. Macfarlane; M. O'Connor; J. Scott; R. Standish; W. Stock; E. Van Etten; G. Wardell-Johnson; and A. Watson (2012). Facilitating adaptation of biodiversity to climate change: a conceptual framework applied to the world's largest Mediterranean-climate woodland. Climatic change 110:227-248.

Queensland Government (2018). SILO Data Drill. https://silo.longpaddock.qld.gov.au/

Raiter K. G. (2016). Enigmatic ecological impacts of mining and linear infrastructure in Australia's Great Western Woodlands. Thesis presented for the degree of Doctor of Philosophy, School of Plant Biology, University of Western Australia. August 2016.

Ramboll (2020a). Audalia Resources Limited Medcalf Project - Dust Deposition Study. 18 June 2020.

Ramboll (2020b). Audalia Resources Limited Medcalf Project - Haul Road Dust Deposition Study. 2 June 2020.

Ramboll (2020c). Audalia Resources Limited Medcalf Project - CFD Wind Study. 17 June 2020.

Raven, R. J. 1985. A revision of the Aname pallida species-group in northern Australia (Anaminae: Nemesiidae: Araneae). Australian Journal of Zoology 33: 377–409.

Rye, B. L. (2007). *New species and keys for Cryptandra and Stenanthemum (Rhamnaceae) in Western Australia*. Nuytsia 16(2): 325-382. ISSN 0085-4417

Saunders, D.A. (1974). The Occurrence of the White-tailed Black Cockatoo, *Calyptorhynchus baudinii*, in Pinus plantations in Western Australia. Australian Wildlife Research. 1:45-54.

Saunders, D.A. (1974b). Subspeciation in the White-tailed Black Cockatoo, Calyptorhynchus baudinii, in Western Australia. Australian Wildlife Research. 1:55-69

Saunders, D.A. (1979). Distribution and Taxonomy of the White-tailed and Yellow-tailed Black-Cockatoos Calyptorhynchus spp. Emu. 79:215--227.

Saunders, D.A. (1980). Food and movements of the short-billed form of the White-tailed Black Cockatoo. Australian Wildlife Research. 7:257--269.

Saunders, D.A. (1982). The breeding behaviour of the short-billed form of the White-tailed Black Cockatoo Calyptorhynchus funereus. Ibis. 124:422--455.

Saunders, D.A. (1986). Breeding season, nesting success and nestling growth in Carnaby's Cockatoo, Calyptorhynchus funereus latirostris, over 16 years at Coomallo Creek, and a methods for assessing the viability of populations in other areas. Australian Wildlife Research. 13:261--273.

Saunders, D.A. & J.A. Ingram (1995). Birds of Southwestern Australia: An Atlas of Changes in the Distribution and Abundance of the Wheatbelt Avifauna. Surrey Beatty and Sons, Chipping Norton, NSW.

Saunders, D.A., I. Rowley & G.T. Smith (1985). The effects of clearing for agriculture on the distribution of Cockatoos in the southwest of Western Australia. In: Keast, A., H.F. Recher, H. Ford & D. Saunders, eds. Birds of Eucalypt Forests and Woodlands. Page(s) 309-321. Surrey Beatty, Sydney.

Sett, R. (2017). Responses in plants exposed to dust pollution. Horticult Int J. 2017;1(2):53-56. DOI: 10.15406/hij.2017.01.00010

Shattock, R. C. (2004). Microcyclic rusts, M-haustoria and Mycophyllas? Field Mycology 5(4).

Sih, A., & Baltus, M.-S. (1987). Patch size, pollinator behaviour, and pollinator limitation in catnip. Ecology, 68(6), 1679-1690.

Sorena, M. and Soderquist, T. (1995). Western Quoll *Dasyurus feoffroyi.* Pp 62 – 64 in Strahan R. (ed). (1995). The Mammals of Australia. Australian Museum / Reed Books.

Storr, G.M. (1987). Birds of the Eucla Division of Western Australia. Records of the Western Australian Museum. Suppl. 27.

Storr, G.M. (1991). Birds of the South-west Division of Western Australia. Records of the Western Australian Museum. Suppl. 35.

Storr, G.M. & R.E. Johnstone (1988). Birds of the Swan Coastal Plain and adjacent seas and islands. Records of the Western Australian Museum Supplement. Suppl. 28:1-76. Perth: Western Australian Museum.

Tille, P. (2006), Soil Landscapes of Western Australia's Rangelands and Arid Interior, Department of Agriculture and Food Western Australia.

Toelken, H. R. (1985). Notes on Teucrium L. (Labiatae). Journal of the Adelaide Botanic Gardens 7(3) 295-300. flora.sa.gov.au/jabg

Tree Society (Inc.), Perth, Western Australia.

Trudgen, M.E. (1991) Vegetation Condition Scale. In: National Trust (WA) 1993 Urban Bushland Policy. National Trust of Australia (WA), Wildflower Society of WA (Inc.).

U.S. Department of Agriculture, Agricultural Research Service. (2007). Systematic Mycology and Microbiology Laboratory – Invasive Fungi Fact Sheets – *Uromycladium tepperianum* on Acacia spp. Retrieved from: /sbmlweb/fungi/index.cfm

Van Dyck, S.; Gynther, I. and Baker, A. Eds (2013). Field Companion to the Mammals of Australia. Queensland Museum.

Walker, K. (1995). Revision of the Australian native bee subgenus Lasioglossum (Chilalictus) (Hymenoptera: Halictidae). Memoirs of the Museum of Victoria, 55(1-2), 1-423.

Watson, A., Judd, S., Watson J., Lam, A. and Mackenzie, D., (2008). The Extraordinary Nature of the Great Western Woodlands. The Wilderness Society of WA.

Wattle. (2018). Acacias of Australia – Acacia hystrix subsp. continua Maslin. Powered by Lucid. Retrieved from https://apps.lucidcentral.org/wattle/

Wege, J. A., & Gibson, N. (2009). A new, rare Marianthus (Pittosporaceae) from the Bremer Range in Western Australia. Nuytsia, 19(2): 295-302.

Western Horticultural Consulting (2019). Soils of the Audalia Medcalf area. Prepared by Neil Lantzke for Audalia Resources Limited.

Western Wildlife (2017), Earl Grey Lithium Project: Level 2 vertebrate fauna survey with targeted Chuditch and Malleefowl surveys, 2016 – 2017. (Available at: http://www.epa.wa.gov.au/sites/default/files/per_documentation2/appendix%203b%20-%20vertebrate%20fauna%20survey.pdf)

Wilderness Society (2020). Great Western Woodlands. Retrieved from: https://www.wilderness.org.au/work/great-western-woodlands

Willmer, P., Cunnold, H., & Ballantyne, G. (2017). Insights from measuring pollen deposition: quantifying the pre-eminence of bees as flower visitors and effective pollinators. Arthropod-Plant Interactions, 1-15. doi:10.1007/s11829-017-9528-2

Wilson, S. and Swan, G. (2017). A Complete Guide to Reptiles of Australia. Fifth Edition, Reed, New Hodland, Sydney.

World Technical Services Group Pty Limited (2019). Audalia Resources Limited Medcalf Project. Geomorphology of the *Marianthus Aquilonaris* sub-populations. Bremer Range West Australia. December 2019.

World Wide Wattle. (2018). Acacia mutabilis. Retrieved from: http://worldwidewattle.com/speciesgallery/mutabilis.php

Zurbuchen, A., Landert, L., Klaiber, J., Müller, A., Hein, S., & Dorn, S. (2010). Maximum foraging ranges in solitary bees: only few individuals have the capability to cover long foraging distances. Biological Conservation, 143(3), 669-676.

15 APPENDICES

Appendix 1: Geotechnical Desktop Study of Pit North Shell Stability Memorandum (Knight Piesold, 2019)

Appendix 2: Soils of the Audalia Medcalf area (Western Horticultural Consulting, 2019)

Appendix 3: Flora and Vegetation reports

- 3.1 Geomorphology of the *Marianthus aquilonaris* sub-populations. Bremer Range West Australia (Word Technical Services Group Pty Limited, 2019)
- 3.2 Component 2 Report. Assessment of genetic diversity in sub-populations of *Marianthus aquilonaris* (DBCA, 2019)
- 3.3 *Marianthus aquilonaris* demographic monitoring: spring 2018 - spring 2019 (Botanica, 2020a)
- 3.4 *Marianthus aquilonaris* landform monitoring: spring 2018 (Botanica, 2019)
- 3.5 Deposition Study (Ramboll, 2020a)
- 3.6 Haul Road Dust Deposition Study (Ramboll, 2020b)
- 3.7 CFD Wind Study (Ramboll, 2020c)
- 3.8 Germination memo (Botanica, 2020b)
- 3.9 Detailed Flora & Vegetation Survey Medcalf Vanadium Mining Project & Proposed Haul Road (Botanica, 2020c)
- 3.10 Flora and Vegetation Impact Assessment (Botanica, 2020d)
- 3.11 Summary on ecology of *Marianthus aquilonaris* (Botanica, 2020e)
- 3.12 Detailed maps of significant flora records
- 3.13 Evaluation of the Effects of Mineral Dust Deposition (Doley, 2020)
- 3.14 Critical Habitat Assessment-Eucalyptus rhomboidea and Stenanthemum bremerense Prepared For Audalia Resources Limited (Botanica, 2020f)

Appendix 4: Mine Closure Plan

Appendix 5: Fauna reports

- 5.1 Fauna survey. Medcalf Vanadium Mining Project (Harewood, 2020a)
- 5.2 Short-range Endemic Fauna Report (Bennelongia, 2020a)
- 5.3 Fauna Assessment. Medcalf Vanadium Mining Project. Proposed Haul Road (Harewood, 2020b)
- 5.4 Insect visitors to *Marianthus aquilonaris* and surrounding flora (Prendergast, 2019)

Appendix 6: Assessment of Subterranean Fauna Values (Bennelongia, 2020b)

Appendix 7: Terrestrial Environmental Quality reports

- 7.1 Geochemical Characterisation of Slurry Samples of Deslimed-Tailings and Gravity-Reject-Tailings and Implications for Tailings Management (GCA, 2020a)
- 7.2 Characterisation of Mine-Waste Samples from Vesuvius, Fuji and Egmont Pits – Implications for Mine-Waste Management (GCA, 2020b)
- 7.3 Brief description of Medcalf geology Memo (Butler, 2020a)
- 7.4 Technical Memorandum: Response to EPA on Waste Rock Sampling (Butler, 2020b)
- 7.5 Tailings Storage Facility Design Concept (Golder, 2020)
- 7.6 Tailings Storage Facility Closure Design Report (Mine Earth, 2020)

Appendix 8: Hydrology reports

8.1 Medcalf Hydrogeological and Hydrological Study Surface Water Assessment (GRM, 2020)

8.2 Groundwater Supply Investigation Audalia Resources Limited Medcalf Vanadium Project (GRM, 2020)

8.3 Medcalf Hydrogeological and Hydrological Study Characterisation of *Marianthus aquilonaris* Habitat (GRM, 2020)

8.4 Medcalf Vanadium Project – Haul Road Water Supply. Technical Memorandum (GRM, 2020)

Appendix 9: GHG Estimation (Just Design Engineering, 2019)

Appendix 10: Dust Control Management Strategy (Ramboll, 2020c)

Appendix 11: Shape files of Development Envelopes and Indicative Disturbance Footprint

Appendix 12: Offset Strategy